Utilization of baglog waste as bokashi fertilizer with local microorganisms (MOL) activator

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Abstract. The purpose of the research is to producing bokashi fertilizer from baglog waste treatment with variations of effective microorganism (EM-4) activator, local microorganism (MOL) papaya, MOL banana hump, and MOL cow dung. The research was conducted in February - March 2019 in the central hydroponics greenhouse of Agro Tourism Cilangkap, East Jakarta. Baglog waste as bokashi fertilizer was made with 6 treatment combinations (P0 – P5). The measured bokashi parameters included nutrient content of Carbon (C), Nitrogen (N), Phosphorus (P) and Potassium (K). These parameters were then compared with compost quality standards according to SNI 19-7030-2004. The results showed that bokashi fertilizer was able to be made within 21 days, in which the nutrient content parameters were in accordance with SNI 19-7030-2004. Overall, the resulting bokashi fertilizer contains much higher K elements than N and P. The findings confirmed that bokashi fertilizer with MOL activator has superior quality (in C, N, P, and K content) compared to that of with EM-4 activator.

1. Introduction

The growing business of oyster mushrooms in Indonesia is parallel to an increase in the waste generation. The waste produced from the cultivation of oyster mushrooms is in the form of baglog waste, also known as baglog. Baglog is formed from the remnants of planting media in which composed of the mixture of sawdust with ingredients such as bran, wheat flour, corn flour, and chalk/ gypsum, which longer effective to be re-used for producing mushrooms [1]. Total baglog waste produced from oyster mushroom cultivation depends on the size and type of business. Generally, one oyster mushroom farmer can produce 500 – 1000 baglogs per harvest. A baglog generally has a weight of 1.2 kg with a production period of three to four months [2]. Untreated baglog waste can accumulates in the nature and cause detrimental effects to surrounding environment [3].

Baglog waste still contains a number of nutrients such as Ca, Mg, P, K, Na, Fe, Zn, Mn, Cu, C, and N [4]. This makes baglog waste can still be used to grow other plants. According to Sulaeman [2], baglog waste has a nutrient content such as total N of 0.6 %, P of 0.7 %, K of 0.02 %, and C-organic of 49.00 %, thus it is beneficial to increase soil fertility. In addition, based on these nutrient contents, baglog waste is potential to be used as organic fertilizer through the implementation of composting technology.

One type of organic fertilizers widely developed by the community is bokashi. Bokashi is also called fermented compost. Bokashi is a technique of composting through a fermentation process or
fermentation of organic matter by addition of Effective Microorganisms (EM) [5]. By using this technology, the composting period can be shortened [6].

Furthermore, bokashi fertilizer can also be made with the addition of local microorganisms (MOL) as an alternative to replace the function of EM-4 solution [7]. MOL composed of microorganisms that are used as starters in the making of solid and liquid organic fertilizers. MOL has an advantage over EM4 due to its naturally available ingredients in the environment.

MOL can be produced from vegetable or animal ingredients [9]. One of vegetable ingredients potential to be used as MOL is papaya. According to Nappu [10], MOL papaya contains several microorganisms such as Actinomycetes, cellulolytic bacteria and cellulolytic fungi that play a key role in the decomposition of organic matter. MOL papaya has the ability to break down organic matter better than MOL banana skin, pineapple skin, cabbage waste, water hyacinth, and lantoro [11]. Another potential vegetable material as MOL is banana hump. Types of microorganisms found in MOL banana hump are Azospirillum sp., Bacillus sp., Azotobacter sp., and Aspergillus niger [12]. In addition, one of the animal ingredients potential as MOL is cow dung. Microorganisms found in cow dung include approximately 60 species of bacteria (Bacillus sp. and Lactobacillus sp.), fungi (Aspergillus and Tricoderma), nearly 100 species of protozoa and yeast. Most of the bacteria found in cow dung are cellulose-, hemicellulose-, and pectin-degrading bacteria [13]. Therefore, this study was aimed to valorise baglog waste as bokashi fertilizer to provide an alternative solution in reducing the volume of untreated baglog waste.

2. Materials and Method

2.1. Time and location of research

The study was conducted from February to March 2019 in the Central Hydroponic Greenhouse of Agro Tourism Cilangkap, East Jakarta.

2.2. Materials

The materials used in the study were baglog waste, EM-4, cow manure, cow dung, banana hump, papaya waste, rice washing water, old coconut water, red sugar, brown sugar, and water.

2.3. Experimental set-up

Bokashi fertilizer was made from different materials combinations with the total of 6 treatment combination (P0 - P5), as shown in Table 1. The composition of the ingredients in each combination was adjusted based on the guidelines for making bokashi fertilizer, as reported by BPTP Central Kalimantan [14].

| Treatment ID | Composition of ingredients |
|--------------|----------------------------|
| P0 (control) | baglog waste (5 kg) + water (2 L) |
| P1           | baglog waste (4 kg) + cow manure (1 kg) + molasses (20 mL) + water (2 L) |
| P2           | baglog waste (4 kg) + cow manure (1 kg) + EM-4 solution (20 mL) + molasses (20 mL) + water (2 L) |
| P3           | baglog waste (4 kg) + cow manure (1 kg) + MOL papaya (20 mL) +m (20 mL) + water (2 L) |
| P4           | baglog waste (4 kg) + cow manure (1 kg) + MOL banana hump (20 mL) + molasses (20 mL) + water (2 L) |
| P5           | baglog waste (4 kg) + cow manure (1 kg) + MOL cow dung (20 mL) + molasses (20 mL) + water (2 L) |

2.4. Making of local microorganism (MOL) solution

Making MOL solution was carried out by smoothing 200 g of each MOL ingredient (papaya, banana hump, and cow dung). Then, each smoothed MOL ingredients was mixed with 200 mL of old coconut water, 200 mL of rice washing water, and 50 g of crushed brown sugar. All ingredients were
thoroughly stirred until homogeneous, placed in a closed container and stored for 2 weeks. The stored MOL solution was then filtered and poured in a plastic bottle [1].

2.5. Making of molasses solution
Red sugar was weighted for 250 g and dissolved in 500 mL of water. This mixture was then thoroughly stirred until homogeneous and poured in a plastic bottle [14].

2.6. Making of bokashi fertilizer
Organic waste materials (i.e. baglog waste and cow manure) were mixed according to treatment combination in Table 1. These waste mixtures were then added with EM-4 solution, MOL papaya, MOL banana hump, MOL cow dung, water and molasses, following the chosen dosage. All ingredients were thoroughly mixed and analysed for the moisture content/MC (chosen ideal value of ~50%). The mixtures were fermented for 21 days in a tightly closed plastic barrel. The composting temperature was maintained between 40–50 °C. The temperature was measured twice a day to control and monitor the temperature fluctuation. If the temperature was too, the mixture was turned over and let stand until the temperature drops, then barrel was closed [14].

2.7. Analysis
Nutrient content parameters such as Carbon (C), Nitrogen (N), Phosphorous (P), and Potassium (K) were measured after the composting process, and were carried out at Balittro Laboratory, Bogor.

2.8. Data analysis
Analysis of the parameter data was carried out using descriptive method, then compared with the Indonesian quality standards of organic compost based on SNI 19-7030-2004 [15].

3. Results and Discussion
The nutrient contents in compost reflects the quality of compost. During the composting process, organic material is decomposed by microorganisms into compost which is rich in both macro and micro nutrients needed by plants [16]. Macro-nutrients, which is need by plants in large quantities (0.1 – 5 %), include C, Hydrogen (H), Oxygen (O), N, P, K, Sulfur (S), Calcium (Ca) and Magnesium (Mg). The elements C, N, P, K are often referred as primary macro-nutrients as these elements can limit plant growth [17]. The nutrient contents of bokashi fertiliser from baglog waste are shown in Table 2.

| Treatment ID | Nutrient content (%) |
|--------------|----------------------|
|              | C  | N  | P  | K  |
| P0 (control) | 54.52 | 0.97 | 0.40 | 1.28 |
| P1           | 49.70 | 1.33 | 1.04 | 2.03 |
| P2           | 49.32 | 1.10 | 0.58 | 2.24 |
| P3           | 45.52 | 1.31 | 0.57 | 2.17 |
| P4           | 41.30 | 1.36 | 0.66 | 2.27 |
| P5           | 42.60 | 1.26 | 0.68 | 2.25 |
| Average      | 47.16 | 1.22 | 0.65 | 2.04 |
| SNI 19-7030-2004 [15] | 9.8-32 | >0.40 | >0.10 | >0.20 |

3.1. Carbon (C)
Carbon is an energy source for microorganisms. Carbon decomposition that occurs is a decomposition of water soluble organic carbon. Organic water soluble carbon is a small part of organic carbon, which decomposition process requires sufficient moisture content [18].
In the opinion of Lu et al. [19], carbon content and moisture content have a negative relationship, where an increase in the moisture content decreases the carbon content. In contrast, this study showed different results where the combination of bokashi fertilizer with high moisture content actually demonstrated high carbon content. This can be seen in the treatment combination of P0 and P1, in which the resulted bokashi fertiliser contains high moisture content (65 %) and carbon content (54.52 % and 49.70 %), respectively. This is possibly due to a high moisture content of the raw compost mixture material, which hindering the composting process and causing incomplete carbon decomposition. According to Kusuma [20], the increasing moisture content in compost material causing the carbon content to increase.

Based on Table 2, it can be seen that P0 has resulted bokashi fertiliser with highest carbon content (54.52 %) compared to that of other treatments (P1 - P5). This shows that during the composting process the carbon content tends to decrease. According to Rahmah et al. [1], during the composting process, the microorganisms using carbon as a nutrient for their growth and development. Pace et al. [21] stated that, in the composting process, carbon is emitted in the form of CO2 along with water vapor and heat energy. While Farius et al. [22] added that the carbon content found in compost raw materials is decomposed into methane (CH4) and carbon dioxide (CO2), which further released into the atmosphere.

Overall, the average carbon content of baglog waste bokashi fertiliser was 47.16%. This value was not much different from previous study by Sulaeman [2] who reported that the carbon content of baglog waste composted for 30 days was 48.50 %. This value was not in agreement with the Indonesian compost quality standards (SNI 19-7030-2004), the carbon content in compost should be between 9.28 - 32%. This is because the main composition of baglog waste is wood powder [1], which contains cellulose of 40 %, hemicellulose of 23 %, and lignin of 34 % [23].

Cellulose is a major component of plant cell walls and is almost never found in pure conditions in nature, but binds to lignin and hemicellulose to form lignocellulose. Cellulose is composed of glucose polymers with β-1,4 glucoside bonds in a straight chain. Bonds of β-1,4 glucosides in cellulose fibers can be broken down into glucose monomers by acidic or enzymatic hydrolysis [24]. In plants, hemicellulose acts as a matrix of cellulose. In general, the hemicellulose fraction of plants consists of a collection of polysaccharide polymers with a lower degree of polymerization compared to cellulose. Hemicellulose is relatively easier to hydrolyze with acids into monomers containing glucose, mannose, galactose, xylose and arabinose.

Lignin is a polymer with an aromatic structure that is formed through propillating units that are interconnected by several different types of bonds [25]. Lignin is difficult to degrade by hydrolysis enzymes because the structure is complex and heterogeneous [26]. Therefore, high lignin content may cause the degradation process of organic matter in composting process to become incomplete, contributing to high carbon content in the resulted compost or bokashi fertiliser.

3.2. Nitrogen (N)
Nitrogen is one of the nutrients needed by leaf vegetables. Nitrogen in the soil is available in two forms, namely inorganic and organic forms. Nitrogen is absorbed by plants in the form of inorganic compounds - i.e. nitrate (NO3−) and ammonium (NH4+). Nitrogen in organic form cannot be directly absorbed by plants but must be overhauled from the organic form into inorganic forms, thus nitrogen becomes available to plants [27]. Nitrogen is an element needed to form important compounds in cells, including proteins, DNA and RNA. Nitrogen is absolutely needed in large quantities for the continuity of plant growth and development [28].

Table 2 shows that nitrogen levels in treatment combination of P1 to P5 tend to be much higher than from P0 (control). This is due to the decomposition of proteins found in compost material. According to Winarso [29], nitrogen levels are relatively increased due to the breakdown of proteins found in compost material into amino acids by microorganisms to produce ammonia (NH₃) and ammonium (NH₄+) compounds.
Furthermore, nitrogen levels are related to carbon content. Increased nitrogen levels can also be due to decomposition of carbon into CO$_2$, thus decreased carbon content is offset by an increase in nitrogen levels [1]. This is indicated by the treatment combination of P4 which contains the highest nitrogen content (1.36 %) despite of its lowest carbon content (41.30 %) (Table 2).

Overall, the nitrogen content contained in all treatment combinations has met the compost standard criteria of SNI 19-7030-2004 with the minimum nitrogen content of 0.40 %.

3.3. Phosphorus (P)
Phosphorus is the second important nutrient for plants growth after nitrogen. Phosphorus is generally absorbed by plants as primary orthophosphate (H$_2$PO$_4^-$) or secondary form (HPO$_4^{2-}$) [30]. Based on Table 2, it can be seen that the highest P level is contained in the treatment combination P1. This is possible because of the presence of phosphate solvent microorganisms that dominate the combination. According to Illmer et al. [31], phosphate solvent microorganisms are a group of microorganisms obtained from external sources and play an important role in the supply of phosphate elements. Phosphate solvent microorganisms dissolve phosphate, thus the phosphate becomes available to be absorbed by plants.

In treatment combination P1, there was no compost activator, but only a mixture of ingredients in the form of cow manure. The composting process on P1 only relied on indigenous microorganisms found in the main ingredients and compost mixture. Novitasari (2017) stated that baglog waste as the main ingredient of compost contains a number of cellulolytic bacteria able to utilize wood powder for their growth. Cow manure as a compost mixture made from processed cow manure containing abundant microorganisms, as described above. Similarly, cow dung also contains indigenous degrading bacteria such as for cellulose, hemicellulose, and pectin [13]. Based on the content of microorganisms found in baglog waste and cow dung, some of them are phosphate solvent microorganisms. These microorganisms include Aspergillus sp., Bacillus sp., and some of the cellulolytic bacteria group are phosphate solvent bacteria.

Overall, P levels in all treatment combinations has met the compost standard criteria (SNI 19-7030-2004) with the minimum P content of 0.10 %.

3.4. Potassium (K)
Potassium is a nutrient that acts to help the enzymatic process in the formation and transport of carbohydrates [33]. Potassium is not found in protein, protolasma, and cellulose. Potassium is not an element in the formation of organic matter, but it plays a role in helping the formation of proteins and carbohydrates [34].

Table 2 shows that the bokashi fertilizer from baglog waste contains higher K element than that of the N and P elements. This is possibly due to the ingredient composition (i.e. mixture of corn flour and wheat flour) found in baglog waste, as explained by Rahmah et al. [1].

According to Suarni and Widowati [35], corn flour contains K levels with the value of 324.8 mg/100 g. Potassium contained in corn flour shows the highest levels compared to other minerals such as P, Mg, Na, Ca, Fe, Zn, Cu and Mn. Wheat flour also contains high K levels reaching the value of 4,363 mg/kg. Potassium contained in wheat flour shows the highest levels compared to other minerals. High K levels in corn flour and wheat flour (as mixture in baglog waste) contributed to a high K content in the resulted bokashi fertilizer.

High potassium levels in baglog waste, bokashi fertilizer, might also be due to the addition of cow manure and activators. According to Widyasrama et al. [36], cow manure contains 1.67 % nitrogen, 1.11 % phosphorus, and 0.56 % potassium. Nutrient content contained in EM-4 activators and MOL is shown in Table 3.
Table 3. Nutrient content of EM-4, MOL papaya, MOL banana hump, and MOL cow dung

| Nutrient content | EM-4   | MOL papaya | MOL banana hump |
|------------------|--------|------------|-----------------|
| N                | 0.68 % | 1.16 %     | 1.73 %          |
| P                | 0.013 %| 0.05 %     | 0.10 %          |
| K                | 0.84 % | 0.07 %     | 0.13 %          |
| Source           | Packaging label of EM-4 | [7] | [7] |

The P0 treatment combination contains the lowest potassium element when compared to other treatment combinations. This is because the source of potassium comes only from baglog waste materials. In P0 treatment, there was no mixture of cow manure or activator. Overall, the K content in bokashi fertilizer from baglog waste meets the compost quality standards (SNI 19-7030-2004) with the minimum K content of 0.20 %.

4. Conclusions
In conclusion, this study demonstrated that baglog waste can be transform into bokashi fertilizer within 21 days. The quality of the resulted bokashi fertiliser was well within the compost quality standards (SNI 19-7030-2004), in terms of nitrogen, phosphorus and potassium content. The finding also confirmed that, in all treatment combination, the level of K elements in the bokashi fertiliser was much higher than the level of N and P content. Bokashi fertilizer from baglog waste with the use of MOL activator showed higher nutrient content compared to that of with EM-4 activator.

References
[1] Rahmah N L, Setyaningtyas N A, Hidayat N 2016 Characteristics of compost made of oyster mushroom baglog (a study of EM4 and sheep manure concentration) Industria: J Teknologi dan Manajemen Agroindustri 41 1-9. [In Indonesian]
[2] Sulaeman D 2011 Effect of compost made of oyster mushroom (Pleurotus ostreanus) baglog waste on the soil’s physical characteristics and on the seed of yellow passion fruit (Passiflora edulis var. Flavicarpa degner), Undergraduate Thesis, Institut Pertanian Bogor, Bogor. [In Indonesian]
[3] Kasmawati, Nadi P, Nurmiati 2013 Growth of oyster mushroom (Pleurotus ostreatus L.) mycelium on baglog waste cultivation media, Prosiding Semirata FMIPA Universitas Lampung, Bandar Lampung. [In Indonesian]
[4] Jonathan S G, Lawal M M, Oyetunji O J 2011 Effect of spent mushroom compost of Pleurotus pulmonarius on growth performance of four Nigerian vegetables Mycobiol. 39 3 164-169.
[5] Tabun A C, Ndoen B, Leo Peu C L, Jermias J A, Foenay T A Y, Ndolu D A J 2017 Utilization of waste in the production of bokashi and organic liquid fertilizers in Tuatuka Village, East Kupang District J. Pengabdian Masyarakat Peternakan 22 107-115. [In Indonesian]
[6] Mayer J, Scheid S, Widmer F, Fliebach A, Oberholzer H R 2010 How effective are ‘Effective Microorganisms (EM)’? results from a field study in temperate climate Appl. Soil Ecol. 46 230-239.
[7] Maryana, Suyadi 2017 Utilization of agricultural waste for making MOL (Local Microorganisms) in Bawuran Village Prosiding Seminar Nasional Tahun ke-3 dan Pameran Hasil Penelitian dan Pengabdian Masyarakat Kemenristekdikti RI, Yogyakarta. [In Indonesian]
[8] Parawansa I N R, Ramli 2014 Local microorganisms (MOL) banana and papaya fruit on the growth of sweet potato plants (Ipomea batatas L.) J. Agrisistem 10 1 10-15. [In Indonesian]
[9] Rohani S T, Sirajuddin S N, Said M I, Mide M Z, Nurhapsa 2017 Model of cow urine utilisation as liquid organic fertiliser in Liburen District Bone Regency J. Panrita Abdi 11 11 11-15. [In Indonesian]
[10] Nappu B 2011 Effectiveness of the use of some local microorganisms (MOL) in processing cocoa waste into organic fertilizer and its application in productive cocoa plants. Retrieved from http://sulsel.litbang.pertanian.go.id/ on 6 October 2018. [In Indonesian]
[11] Palupi N P 2015 variety of local microorganism solution as decomposer of elephant grass (Pennisetum purpureum) Ziraa’ah 40 2 123-128.
[12] Kesumaningwati R 2015 Use of MOL banana hump (Musa paradisiaca) as decomposer in composting of oil palm empty fruit bunches Ziraa’ah 40 1 40-45.
[13] Bai S, Kumar M R, Kumar D J M, Balashanmugam P, Kumaran M D B, Kalaichelvan P T 2012 Cellulase production by Bacillus subtilis isolated from cow dung Scholars Res. Library 4 1 269-279.
[14] Balai Penelitian Tanah Pertanian Central Kalimantan 2013 making of compost with Em4 activator. Retrieved from http://kalteng.litbang.pertanian.go.id on 8 Mei 2019 [In Indonesian]
[15] Standar Nasional Indonesia/SNI 19-7030 2004 Specification of compost from organic domestic waste, Badan Standardisasi Nasional, Jakarta. [In Indonesian]
[16] Widarti B N, Wardhini W K, Sarwono E 2015 Effect of C/N ratio of raw material on composting of cabbage and banana peels. Integrasi Proses 5 2 75-80. [In Indonesian]
[17] Munawar A 2011 Soil;s Fertility and Plant’s Nutrient IPB Press Bogor. [In Indonesian]
[18] Sparling G, Vojvodic-vukovic M, Schipper L A 1998 Hot water soluble C as simple measure of labile soil organic matter: the relationship with microbial biomass C Soil Biol. Biochem. 30 10 1469-1472
[19] Lu Y, Wu X, Jifeng G 2009 Characteristic of municipal solid waste and sewage sludge composting Waste Manage. 29 3 1152-1157.
[20] Kusuma M A 2012 Effect of moisture content variation of the decomposition rate of organic waste compost in Depok City, Postgraduate Thesis, Universitas Indonesia, Depok. [In Indonesian]
[21] Pace M G, Miller B E, Farrell-Poe K L 1995 The Composting Process, Utah State University Cooperative Extension, Utah.
[22] Farius S, Salafudin R, Lathifa, Apriani E 2011 Integrated utilisation of organic waste as alternative energy source biogas and briquette precursor Prosiding Seminar Nasional Teknik Kimia, Institut Teknologi Nasional, Yogyakarta. [In Indonesian]
[23] Hartati S, Sudarmonowati E, Park Y W, Kaku T, Kaida R, Baba K, Hayashi T 2008 Overexpression of poplar cellulase accelerate growth and disturbs the closing movements of leaves in sengon Plant Physiol. 147 2 552-561.
[24] Lynd L R, Weimer P J, Van-Zyl W H, Pretorius I S 2002 Microbial cellulose utilization: fundamental and biotechnology Microbiol. Molecul. Biol. Rev. 66 506-577.
[25] Perez J, Munoz-Dorado J, de la Rubia T, Martinez J 2002 Biodegradation and biological treatments of cellulose, hemicellulose and lignin: an overview Int. Microbiol. 5 53-63.
[26] Hofriechter M 2002 Review: lignin conversion by manganese peroxidase (MnP) Enzyme Microbiol. Technol. 30 454-466.
[27] Tisdale S L, Nelson W L, Beaton J D 1990 Soil Fertility and Fertilizer, McMillan Publishing Company, New York.
[28] Miftahudin 2008 Basic Plant Physiology Fisiologi Tumbuhan Dasar, Departemen Biologi FMIPA IPB, Bogor. [In Indonesian]
[29] Winarso S 2005 Soil Fertility Basic Health and Soil Quality, Gava Media, Yogyakarta. [In Indonesian]
[30] Hardjowigeno S 2010 Soil Science, Akademika Pressindo, Jakarta. [In Indonesian]
[31] Illmer P A, Barbato F, Schinner 1995 Solubilization of hardly-soluable AlPO4 with P-solubilizing microorganism Soil Biol. Biochem. 27 3 265-270.
[32] Novitasari D 2017 Isolation and enzymatic selection of cellulytic bacteria from white oyster mushroom (Pleurotus ostreatus) made of rubber wood sawdust (Hevea brasiliensis Muell.
Arg), Undergraduate Thesis, Universitas Islam Negeri Raden Intan, Lampung. [In Indonesian]

[33] Astari L P 2011 Quality of horse bedding compost fertiliser using different microbial activators, Undergraduate Thesis, Institut Pertanian Bogor, Bogor. [In Indonesian]

[34] Hidayati Y A, Harlina E, Marlina E T 2008 Effort to process sheep and stool waste (Vitiveria zizanioides) using various composting methods J. Ilmu Ternak 8 1 87-90. [In Indonesian]

[35] Suarni, Widowati S 2015 Structure and Nutrition of Corn and Wheat. Balai Penelitian Tanaman Serealia. Retrieved from http://balitsereal.litbang.pertanian.go.id/ on 5 Me 2019. [In Indonesian]

[36] Widyasmara L, Pratiwiningrum A, Yusiat I M 2012 Effects of livestock manure type as substrate with addition of teak leaf waste (Tectona grandis) on biogas characteristics from fermentation process Buletin Peternakan 36 1 40-47. [In Indonesian]