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Content from this work may be used under the terms of the CreativeCommonsAttribution 3.0 licence. 10 Any further distribution of this work must maintain attribution to the author(s) and the title of the work, journal citation and DOI. Published 13 under licence by IOP Publishing Ltd 1st Lekantara Annual Conference on Natural Science and Environment (LeNS 2021) IOP Conf. 6 Series: Earth and Environmental Science 1097 (2022) 012020 IOP Publishing doi:10.1088/1755-1315/1097/1/012020 1 Trichoderma sp. 1 Breeding from Bamboo Stems (Schizostachyum brachycladum) and Its Application as an Inoculant for Organic Fertilizer Fermenters According to SNI 7763:2018 Ramaiyulis and Setya Dharma* Politeknik Pertanian Negeri Payakumbuh, Lima Puluh Kota, Sumatera Barat 26271 Indonesia *setyad80@gmail.com Abstract. This research is an applied study involving the Al Falah farmer group in West Sumatra, Indonesia and was intended to develop a quality organic fertilizer processing technology based on SNI-7763:2018. 1 A Trichoderma sp. culture was bred using bamboo stems (Schizostachyum brachycladum) on a bran medium in an incubator at 39 °C and 75% RH. Cow feces was air-dried for reduced water content from 82% to 60%, mixed with poultry feces (at a ratio of 60:40), and added with 0.3% Trichoderma sp. culture. The mixture was then stacked at a thickness of 70 cm for 7 days. The fermentation results showed an average fermentation temperature of 58 °C and changes in the pH of cow feces and poultry feces from 8.8 to 7.2 and from 3.6 to 6.8, respectively. The following data were also obtained: macronutrient content N = 2.82%, P = 2.78%, and K = 3.21%; organic matter content = 82.89%; C-organic content = 21.20%; C/N ratio = 7.52; and by-products = 1.02%. Based on the results of this research, the organic fertilizer produced complies with SNI-7763:2018. Keywords: Organic fertilizer; Trichoderma sp.; Bamboo; Incubator; Cow feces.

1. Introduction

Cattle manure is a threat to the environment and at the same time a potential source of income for livestock farmers. It is important to perform cattle manure waste management soundly so as not to pollute the water environment, the air, and even vegetation [1]. Piles of cattle manure will be fermented by indigenous microorganisms that produce methane gas and nitric oxide, all of which have contributed 20–30% of greenhouse gases from the agricultural sector [2]. Conversely, cattle manure that is processed into organic fertilizer can be an additional potential for farming income, leading to waste conversion into a co-product of livestock farming [3]. Liquid and solid cattle waste has an advantage as fertilizer. Liquid waste (urine) contains growth plant stimulants [4], while the slurry biogas digester waste from cow dung can be used as nutrients for hydroponics [5]. Farmers' practice of processing cattle manure into organic fertilizer has actually been around for a long time. The product is known as manure fertilizer, i.e., cattle manure which is piled up behind the cage until it dries up and brought to the field as plant fertilizer. However, the quality of this manure fertilizer is still low and its response to plants is slow. This is because the fermentation of manure is imperfect, thereby taking it some time to decompose in the soil before it can be absorbed by the roots of plants. Manure fertilizer has been reported to have the following nutrient content: N = 0.4%; P = 0.2%; and K2O5 = 0.1% [6]. This content is considered low according to the standards prevailing in the Republic of Indonesia. In this case, the Indonesian Government through the Regulation of the Minister of Agriculture No. 11-2011 requires a minimum amount of N + P + K of 4%. Efforts to improve the quality of organic fertilizers aim to encourage increased use of organic fertilizers and reduced use of inorganic fertilizers in the agricultural sector. In recognition of the dangers of inorganic fertilizer use, the Indonesian Government encourages the use of organic fertilizers by providing organic fertilizer production equipment. The Al Falah Farmer Group is one of the recipients of the Organic Fertilizer Processing Unit ("UPPO") aid under the Agriculture and Food Crops Office of West Sumatra Province in 2011. Based on the field observation reports of the Livestock and Animal

 Health Service Office of West Sumatra Province, 72% of UPPOs in West Sumatra underperformed in their production. The Al Falah Farmer Group is one of the UPPOs in West Sumatra that demonstrates a low production level. Some of the problems identified were the use of non-standard fertilizer raw materials, an absence of measurement of the quality of the organic fertilizer produced, and poor fertilizer packaging. The solutions offered are to reformulate the raw materials, perform a nutrient analysis in the laboratory, and improve the packaging. This particular activity aims to increase the independence of the group in producing quality organic fertilizers optimally. It is a pilot project to empower 68 UPPOs in West Sumatra Province. 2. Methodology 2.1 Profile of the farmer group The community empowerment activities in producing quality organic fertilizer in partnership with the Al Falah Farmer Group took place in Ompang Tanah Sirah Village, North Payakumbuh District, Payakumbuh City, West Sumatera Province, Indonesia. This farmer group was led by M. Zamzami dt. Jindo Kayo. Operated by 15 members, this farmer group run a beef cattle breeding business. In 2011 the 3 Al Falah Farmer Group received an Organic Fertilizer Processing Unit (UPPO) aid worth 340 million rupiahs. This aid was then used to procure 1 cattle enclosure, 35 Bali cattle, 1 factory building, 1 motorized pedicab, and 1 unit of crusher machinery. The Al Falah Farmer Group was actively expanding its business and currently keeping 31 Simmental cattle. Its organic fertilizer production averaged 5 tons/month. The organic fertilizer produced was marketed in collaboration with several stakeholders, namely CV Delta Jember, the Environment Office of Payakumbuh, and the Department of Food Security of Payakumbuh. It was sold for Rp800/kg. The 26 raw material used for the organic fertilizer production was cattle manure from various cattle farms amounting to 11.6 tons/month. 2.2 Technology Transfer Method The technology transfer from the promotor team to the target audience of the Al Falah Farmer Group was carried out using the "learning by doing" method. The target audience was all members of the Al Falah Farmer Group. However, the transfer of technology was actually performed only on 4 people as target audience, namely the chairman and 3 influential members of the group. The series of stages of technology transfer was expected to lead to the stage of technology adoption by the target audience. It began with the lecture-counseling method to motivate the target audience, followed by a work guidance to the organic fertilizer production process interspersed with discussion and evaluation. 2.3 Reformulation of raw material Reformulation of the raw material of the organic fertilizer was intended to improve the quality of the organic fertilizer produced. Changes to the formula were introduced through community empowerment activities, as shown in Table 1. The production process was carried out at the UPPO factory owned by the Al Falah Farmer Group at 1 ton for each of the old formula and new formula. The old formula consisted of a mixture of cattle manure and husk ash doused with a solution containing 1 liter of effective microorganism 4 (EM4) and 4 liters of water. It was then covered with plastic sheeting and incubated for 3 weeks. The ingredients were stirred at the end of the first week and the second week. The fermentation process was terminated at the end of the third week by opening the plastic sheet cover. The fertilizer was then left to dry for 1 week, ground, and prepared for sale. Meanwhile, the new formula had the same composition but with adjusted water content. If the raw material did not drip water between the fingers when it was clenched, it means that the water content of the material was appropriate (around 50%) for the raw material to be stacked for fermentation. Conversely, if there was water dropping from the material when clenched, the water content of the material was too high. Therefore, the material would need to be aerated for 24 hours first before being stacked for fermentation. The fermentation process 6 was carried out by stacking the material on the floor ± 60 cm tall and leaving it for 2 weeks without reversal. After the fermentation process was complete, the fertilizer would end up being dry because the fermentation heat would cause the water content of the material to evaporate. In this condition, the fertilizer was ready to be ground. Grinding was performed with a crusher machine with 18 blades (see Figure 1). The ground fertilizer was mashed,

2 1st Lekantara Annual Conference on Natural Science and Environment (LeNS 2021) IOP Conf. 6 Series: Earth and Environmental Science 1097 (2022) 012020 IOP Publishing doi:10.1088/1755-1315/1097/1/012020 3 thereby not requiring sifting. 2.4 Quality parameters analysis A quality analysis was carried out in a laboratory to measure several quality parameters.

Fertilizer water content was determined based on the percentage of total evaporation of water by heating it in an oven at 105 °C for 24 hours. The difference in water content with 100% dry matter was the percentage of dry matter content in organic fertilizer. This analysis was followed with the determination of the levels of organic and inorganic materials by ashing in a furnace at 400 °C. The acidity of the organic fertilizer was [4] determined using a pH meter (Hi9807-phep), the C-organic content was determined by the titrimetry method, and the nitrogen content was determined by the Kjeldahl method. A following proximate analysis [7] was carried out to determine the phosphorus nutrient level. Pollutants were determined from the percentage of the weight of contaminants (plastic, gravel, iron, glass, etc.) in 100 grams of organic fertilizer. Determination of the quality of the organic fertilizer produced was conducted by comparing the results of organic fertilizer quality tests in the laboratory with quality standards. The quality standard used was SNI 7763:2018, which is concerned with organic fertilizers, biological fertilizers, and soil enhancers. The quality comparison was focused on macronutrient [4] content and supporting criteria such as pH, water content, organic matter content, and others. 2.5 Screen Printing of Packaging [19] The screen printing technique was performed on the packaging using a T150 screen and HD glossy vinyl ink. The packaging label was designed with CorelDraw software version 12 and printed with an HP Laserjet Professional P1102w printer. The screen was coated with Ulano 133 emulsion and then dried with a hairdryer for 3 minutes, all in a dark room. Design paper was smeared with coconut oil to make it transparent then placed on the screen. Lighting was applied for 20 seconds. Then, the screen was sprayed with water until the cover sled with water according to the design pattern. Printing was performed by smearing ink on the screen that was placed on top of the package to be printed. The ink was printed on the package according to the screen image pattern. 3 Results And Discussion 3.1. Quality of Organic Fertilizers Table 2 shows that [14] the quality of the organic fertilizer using the new formula was better than that of the organic fertilizer using the old formula. The macronutrient content of nitrogen (N) and phosphorus (P) as main indicators showed that the old formula did not meet the standard, while the new formula did. It was outlined by the Government through SNI 7763:2018 that the minimum content of nitrogen, [27] phosphorus (P2O5), and potassium (K2O) was 4%. [15] In the case of the old formula the content of the three elements was 3.98, while in the case of the new formula the amount of elements N and P, excluding K, was 4.29. In the old formula, there was an imbalance of nutrients, in which case the element K was high (2.54%) while N (0.95%) and P (0.40%) were low. This was due 18 to the use of ashes in the old formula. The use of 100% of cattle manure had not been able to produce quality organic fertilizer. Therefore, it was deemed necessary to add other organic materials. The quality of an organic fertilizer is largely determined by the raw material used [8] and the fermentation process [9]. 5 Meanwhile, the fermentation process is influenced by the C/N ratio, size, composition of the material, the number of microbes, humidity, aeration, temperature, and acidity [10]. The old formula, which used EM4 microbes, contained photosynthetic bacteria that required higher water content in the material. On the other hand, the new formula relied on indigenous microbes, namely the digestive tract microbes that were carried along with animal manure. The fermentation process could take place both aerobically and anaerobically. The aerobic process would produce CO2, H2O, and heat, while the anaerobic process would produce CH4, CO2, and organ [11].

2 1st Lekantara Annual Conference on Natural Science and Environment (LeNS 2021) IOP Conf. Series: Earth and Environmental Science 1097 (2022) 012020 IOP Publishing doi:10.1088/1755-1315/1097/1/012020 4 Table 2 Comparison of the Quality of Organic Fertilizers before and after Service Activities According to SNI 7763:2018 Parameters Score Standard quality of SNI 7763:2018 Quality achievement *) Old formula New formula Old formula New formula ------------------- % -------------------- pH 9.22 8.72 4–9 NS S Water content 8.65 41.86 15–25 NS NS Dry matter 91.3 5 58.14 - - - Inorganic matter 30.1 8 19.83 - - - Organic matter 69.8 2 80.17 - - - C-organic 14.8 8 20.21 Min. 15 S S Nitrogen 0.95 2.11 N+P+K Min. 4 NS S Phosphor 0.40 2.18 NS S Potassium 2.54 - S - C/N ratio 15.6 6 9.58 15–25 S NS Pollutant 1.69 1.45 Max. 2 S S *) S: meets the standards; NS: does not meet the standard The C/N ratio of the old-formula organic fertilizer was 9.58, which had met the standard, while the C/N ratio of the new-formula organic fertilizer was 15.66, which did not meet the standard. The high C/N ratio of the latter was due to the higher C/N ratio of the base material. In addition, the fermentation time was too short so that the C-organic content was still high. Besides, the nitrogen content was also high. In the old formula, the cattle manure had a C/N ratio of 25.00, whereas in the new formula, with the addition of feed residue and rice straw, the C/N ratio was higher at 30.05. A

fermentation process in principle reduces 8 the C/N ratio of raw materials, allowing the organic fertilizer produced to have a C/N ratio identical to or approaching the C/N ratio of the soil. During this process, there will be degradation of organic compounds such as carbohydrates, crude proteins, fats, and minerals by microbes, producing CO2, methane, and water [2]. A fermentation process is optimal at the temperature range of 30–50 °C and 60% humidity. At this temperature range, bacteria and fungi work optimally while pathogenic bacteria and weed seeds will die. 14 The moisture content of the material needs to be considered in order to set the temperature and humidity to be appropriate with the growth of microbes. If the moisture content of the material is too high, the fermentation temperature will be low, which causes the microbes to not work or be dormant. Conversely, if the water content is too low, the fermentation temperature will be high, which can cause the death of the fermentor microbes. Reversal is done if the fermentation temperature is too high (> 60 °C) to keep the microbes from dying and 8 at the same time for aeration. The process of decomposition of basic ingredients into organic fertilizer during the fermentation process is affected by the water content of the ingredients. 14 The moisture content of the ingredients in the old formula (± 80%) was expected to work with the photosynthetic bacteria from EM4 (bacterivores). In the new formula, it was expected to work with indigenous microbes, especially fungi (fungivores), so that the water content was set at ± 50%. Microorganisms decompose organic matter optimally at 40– 60.5% water content [12]. If the water content is too high, the fermentation process will last longer. Conversely, if it is too low, the efficiency of organic matter decomposition will decreases due to a lack of water as solvent of the organic material to be decomposed [13].

12 1st Lekantara Annual Conference on Natural Science and Environment (LeNS 2021) IOP Conf. Series: Earth and Environmental Science 1097 (2022) 012020 IOP Publishing doi:10.1088/1755-1315/1097/1/012020 5 3.2. Packaging and Storage The packaging of 8 the organic fertilizer produced in this activity used 33 x 55 cm plastic sacks. The sacks were branded by screen printing as shown in Figure 2. This packaging type was chosen on the grounds of production cost effectiveness and product protection purpose. Poly-ethylene (PE) plastic packaging was considered good because it was cheap, strong, and capable of protecting the product from the environment, air, humidity, and

water evaporation. Fig. 2. Packaging design and appearance A: Packaging label design B: Ready-to-sell organic fertilizer product On the fertilizer package the fertilizer nutrients content, price, and fertilizer producer (the Al Falah Farmer Group under the supervision of Politeknik Pertanian Negeri Payakumbuh) were displayed. An attractive and informative packaging appearance apparently left a positive image in the customers' minds about the product. The packaging appearance is critical for the fertilizer existence in the market because the fertilizer product must compete with many other organic fertilizer products that have been 19 circulating in the market longer. It has been recorded that as of 2015 there were 753 5 organic, biological fertilizer and soil ameliorating agent brands in Indonesia [14]. 4 Conclusion The processing of organic fertilizer using a new formula with 75% cow dung + 10% feed residue + 15% straw/weed litter could produce quality organic fertilizer in compliance with SNI 7763:2018. Indigenous microbes such as the digestive tract microbes carried along with cow dung could ferment

 the basic ingredients of the fertilizer without the addition of any other inoculant microbes. Fertilizer packaging using plastic bags branded by screen printing with some nutrient information has been able to attract attention and increase the selling power of the organic fertilizer product. The fertilizer was set to expire after 3 months following the decrease of water content during storage down to the standard limit. Acknowledgments The community service activities were funded 15 by the Ministry of Education, Culture, Research, and Technology in 2021 through Program Kemitraan Masyarakat (PKM). Our highest appreciation is due to 25 the Al Falah Farmer Group as an activity partner. The activities may be useful for group empowerment in producing quality organic fertilizer. REFERENCES [1] T. Aluwong, P. A. Wuyep, and L. Allam, "Livestock-environment interactions: Methane emissions from ruminants," African J. Biotechnol., vol. 10, no. 8, pp. 1265–1269, 2011. [2] J. Gao, Y. J. Jing, M. Z. Wang, L. F. Shi, and S. M. Liu, "The effects of the unsaturated degree of long-chain fatty acids on the rumen microbial protein content and the activities of transaminases and dehydrogenase in vitro," J. Integr. Agric., vol. 15, no. 2, pp. 424–

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