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Research Article

Utilization of Coffee Pulp Waste Composted with Cellulolytic Actinomycetes to Enhance Chili Plant Growth

Umi Fatmawati[1]*, Dewi Puspita Sari[1], Meti Indrowati[1], Slamet Santosa[1], Sri Martina Wiraswati[2], Harlita[1]

1) Biology Education Study Program, Universitas Sebelas Maret. Jl. Ir. Sutami 36A Surakarta 57126, Central Java
2) Faculty of Biology, Universitas Jenderal Soedirman, Jl dr. Suparno 63 Purwokerto 53122, Central Java
* Corresponding author, email: umifatmawati@staff.uns.ac.id

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ABSTRACT

The abundant volume of coffee bean pulp as a by-product of the post-harvest processing is an important source of soil organic matter if it is properly handled. The alternative way to use coffee bean pulp waste to reduce the impact of environmental pollution is composting. This study aims to determine the ability of actinomycetes to degrade coffee pulp, to identify the physical and chemical characteristics of coffee pulp compost, and to evaluate the effect of coffee pulp compost on chili plant growth. The results showed that 7 isolates of actinomycetes were able to hydrolyze coffee pulp *in vitro* with a hydrolytic index of 1.7-3.81. The treatment of coffee pulp compost with the addition of a starter of cellulolytic actinomycetes (P2) at the end of the three-week incubation period showed the highest organic N (25 mg/kg), P (7.05 mg/kg), and K (33 mg/kg), t compared to other treatments. The effect of giving coffee pulp compost towards the growth of chili plants shows that the coffee pulp composted with zeolite 5% (w/w) increased the height of the chili plants by 37.6%, while in coffee pulp composted by cellulolytic actinomycetes 5% (v/w) increased the number of leaves by 96% and plant biomass by 25%. Based on the results of this research, coffee pulp compost has the potential to be used as biological fertilizer to increase plant growth, both composted by zeolite and cellulolytic actinomycetes.

INTRODUCTION

Coffee (*Coffea* sp.) is one of the export commodities which plays important role in generating foreign exchange. Based on BPS data, the number of coffee exports was 412.370,3 tons in 2016 and 464.198,3 tons in 2017 (BPS 2018). Increased demand for coffee consumption comes from abroad as well as the domestic market. Unfortunately, the coffee processing industry posses a problem in the utilization of coffee pulp waste into economically valued products. According to previous data, raw coffee cherries processing generated approximately one ton of fruit waste from two tons of raw coffee (Brunerová et al. 2019). Thus, the disposal of coffee pulp waste must be well managed to reduce negative effects on the environment as well as public health.

Coffee pulp waste obtained during the dry and wet coffee processing stages which are wet fruit skin, liquid waste containing mucus, dry logs, and dry shells. Coffee fruit has a moisture content between 60-65%. Coffee cherries are still protected by the outer skin or pericarp, pulp, pectin, endocarp, and silver skin when they are harvested (Klingel et al. 2020). The results of the mass balance analysis showed that 100 kg of processed dry coffee cherries generated 29 kg (29%) of dry logs which consisted of 15.95 kg of coffee beans (55%) and 13.05 kg of dry logs (45%). The dominant composition of dry logs are shell, mucus, and fruit skin. Besides that, the dry logs also contain several compounds such as reducing sugars, non-reducing sugars, pectin compounds, protein, and crude fiber (Widyotomo 2013). Therefore, it is necessary to process coffee pulp waste which has economic value for reducing the impact of environmental pollution.

Composting coffee pulp is an alternative way to reduce the environmental negative impacts caused by coffee bean pulp waste. The abundant volume of coffee hulls as post-harvest processing product are important source of organic matter for soil as long as they are composted properly. After composting process, the coffee pulp waste contains 1.0-2.3 of nitrogen and 8 of C / N ratio to be utilized by plants (Setyorini 2006). The decomposition process of plant residue i.e. coffee pulp waste by decomposer microorganisms produces nutrients that can be easily absorbed by plants. Several types of decomposer microbes have a role in plant residues decomposition i.e. bacteria, fungi and actinomycetes groups. Actinomycetes are a Gram-positive bacteria group which is able to decompose organic materials by producing various types of hydrolytic enzymes such as cellulases, xylanases, pectinases, and proteases. Actinomycetes species are dominated by *Streptomyces* spp. (Soeka et al. 2019).

The role of *Streptomyces* spp. in coffee pulp waste decomposition was investigated in this research. The coffee pulp waste composted by adding *Streptomyces* spp. producing cellulase enzymes as decomposer microbes. These microbes have been previously studied as cellulase and chitinase producers, phosphate solvent, nitrogen providers, and IAA- phytohormones producers (Fatmawati et al. 2019). This study aimed to determine the best nutrient content from coffee pulp composting by *Streptomyces* spp. as a decomposer microbe. In addition, this research aimed to obtain the best compost formulation which can be used as biological fertilizer for increasing the growth of chili plant.

MATERIALS AND METHODS

Materials

In this study, there are several equipments for composting process, namely: polyethylenebuckets with lids 30L in capacity, PVC tube with the diameter of 3 cm, gardening towel, weight scales, pH meters, thermometers, and hand sprayers. In addition, the materials that are used in this study were coffee pulp waste from wet and dry processing (from Banyuanyar, Boyolali, Central

Java), soil, ISP2 medium, actinomycetes isolates namely ASR 45, ASR 47, ASR 49, ASR 58, ASR 67, ASR 69, and ASR 71 (collection of Microbiology Laboratorium Universitas Sebelas Maret), EM4, zeolite, chili seeds as a plant for testing, and water.

Methods

Preparation of coffee pulp

The coffee bean pulp waste was prepared and weighed. Ten grams of samples were used for proximate analysis, including sugar content using the Luff Schroll method (Taufik & Guntarti 2016), fiber and moisture content using the gravimetric method.

Hydrolytic assay of coffee pulp by actinomycetes strain *in vitro*

10 g of coffee pulp powder are added to the ISP4 agar medium (10 g coffee pulp powder, 1 g K_2HPO_4, 1 g $MgSO_4$, 1 g NaCl, 2 g $(NH_4)_2.SO_4$), 2 g $CaCO_3$, 0.1 ml $MgCl_2.7H_2O$, 0.1 ml $FeSO_4$, 0.1 ml $ZnSO_4$, agar 18 g, 1 L distilled water). Afterwards, 4 plugs of 7 days old actinomycetes culture on the ISP2 agar medium were inoculated on ISP4 agar containing coffee pulp powder 1% (v/w) medium and incubated at 28° C for 5 days. After 5 days of incubation, the hydrolytic activity of actinomycetes cellulolytic enzymes was observed by dripping 1% Congo Red solution on the actinomycetes colony. The diameter of the clear zone and the hydrolytic index (HI) value were then measured (Ferbiyanto et al. 2015).

Composting coffee pulp

The composting procedure of coffee pulp waste is as follows: 5 kg of coffee pulp waste were prepared from each wet processing, dry processing, and a mixture of both processes. The coffee pulp waste is then chopped into smaller sizes to facilitate the decomposition process and mixed with manure in a 4: 1 ratio. Each mixture was separated into three parts for four treatments which consist of: (1) EM4 5% (v/w), (2) cellulolytic actinomycetes 5% (v/w) with 10^{-8} CFU/ml, and (3) inorganic activator (Zeolite) 5% (w/w), and (4) combination of cellulolytic actinomycetes 2.5% (v/w) and zeolite 2.5% (w/w). The materials were put into the bucket and tightly covered with plastic lid for a week to permit the fermentation process. In addition, biomass homogenization is carried out by stirring along the fermentation process. The ripened compost was marked by maturity parameters such as compost texture, pH, temperature, and color that were measured and observed at the end of fermentation. Apart from physical parameters, analysis of nutrient content was also carried out involving organic N, P, K, C, and moisture content (Setyorini 2006).

Growth promoter assay of coffee bean pulp compost on chili plants

A greenhouse experiment was conducted to determine the effect of coffee pulp compost on chili plant growth. The experiment was conducted using a

completely randomized design in three replication. The five experimental groups consist of planting medium amended with: (1) coffee pulp composted with EM4 5%, (2) coffee pulp composted with cellulolytic actinomycetes 5%, (3) coffee pulp composted with zeolite 5%, (4) coffee pulp composted with combination of cellulolytic actinomycetes 2.5% + zeolite 2.5%, and (5) soil without compost for the control. Planting chilies begin with sowing chili seeds in planting medium pot containing 3 seeds in each pot. Each replication consisted of 3 pots. The planting medium consists of compost of coffee bean pulp waste and soil with a ratio of 1: 1. The chili plants were then placed in a greenhouse for 6 weeks. After the first 2 weeks of days after planting, the plant height, number of leaves, and plant biomass of the chili plants were observed everyweek.

RESULTS AND DISCUSSION

Proximate content of coffee pulp

The proximate levels of coffee pulp analysis were conducted to determine the amount of sugar and fiber content in the coffee pulp. The data from the proximate analysis of the coffee pulp are presented in Table 1.

Table 1. The results of the coffee pulp proximate analysis.

No	Parameter	Result	unit	Methods
1	Total sugar	0,12	%	Luff Schroll
2	Raw fiber	31,9	%	Gravimetric
3	Total lipid	0, 24	%	Gravimetric

Based on the data above, it is known that the crude fiber content is 31.9% which indicates that fiber is the predominant composition of the coffee pulp. Klingel et al. (2020) stated that the coffee husks are composed of skin, pulp, and parchment. The coffee husk contains 8%–11% of protein, 0.5%–3% of lipids, 3%–7% of minerals, and 58%–85% of total carbohydrates. Meanwhile, the fiber amount of coffee husk contains 24.5% of cellulose, 29.7% of hemicellulose, and 23.7% of lignin. The composition of fiber i.e. cellulose, hemicellulose, and lignin are polysaccharide sugar groups that have β (1-4) glycosidic bonds which tend to be stable and are difficult to hydrolyze.

Therefore, to describe the composition of these compounds, it is necessary to have a source of β (1-4) glycosidase or hydrolytic enzymes that can hydrolyze these polysaccharide compounds. These enzymes are obtained from microorganisms distributed in both prokaryotic and eukaryotic domains including bacteria, fungi, and actinomycetes (Ahmed et al. 2017). Actinomycetes are attractive microbial group for the production of lignocellulose degrading enzymes. They are known as Gram-positive group bacteria that are capable to produce cellulase enzymes and have been applied in several composting processes include coffee pulp. Therefore,the actinomycetes have been always predominantly found in the compost. The addition of

organic compost increased the number of actinomycetes compared to the untreated soil and also provides lower incidence of phytopatogen (Javoreková et al. 2019). Hence, the hydrolysis of coffee pulps in this study was conducted using several strains of actinomycetes.

The hydrolytic activity of actinomycetes in hydrolyzing coffee pulp *in vitro*

The *in vitro* analysis results showed that 7 isolates of actinomycetes have hydrolytic activity with the formation of a clear zone around the bacterial colony (Figure 1). Meanwhile, the hydrolysis index is various among actinomycetes isolates. The highest hydrolysis activity was shown by ASR 45 isolate with a hydrolytic index of 3.85, while the lowest hydrolysis activity was shown by ASR 49 isolate with a hydrolytic index of 1.7 (Table 2).

Table 2. The hydrolytic index of actinomycetes isolates on the coffee pulp substrate using the plug agar method.

No	Isolate Code	Hydrolytic Index (HI)
1	ASR 45	3.81
2	ASR 47	3.04
3	ASR 49	1.79
4	ASR 58	2.00
5	ASR 67	3.04
6	ASR 69	2.71
7	ASR 71	2.13

According to the data above, the 7 isolates of cellulolytic actinomycetes can hydrolyze coffee pulp cellulose and can be used to degrade coffee pulp waste. The ability of actinomycetes isolates to degrade coffee pulp polysaccharides *in vitro* is indicated by the formation of a clear zone around the actinomycetes colony (Figure 1). The coffee pulp in growth medium is hydrolyzed by an extracellular hydrolytic enzyme which is produced by cellulolytic actinomycetes isolates. The type of hydrolytic enzymes produced by actinomycetes isolates is depending on the type of polysaccharide compounds contained in coffee pulp waste. Some actinobacteria were reported

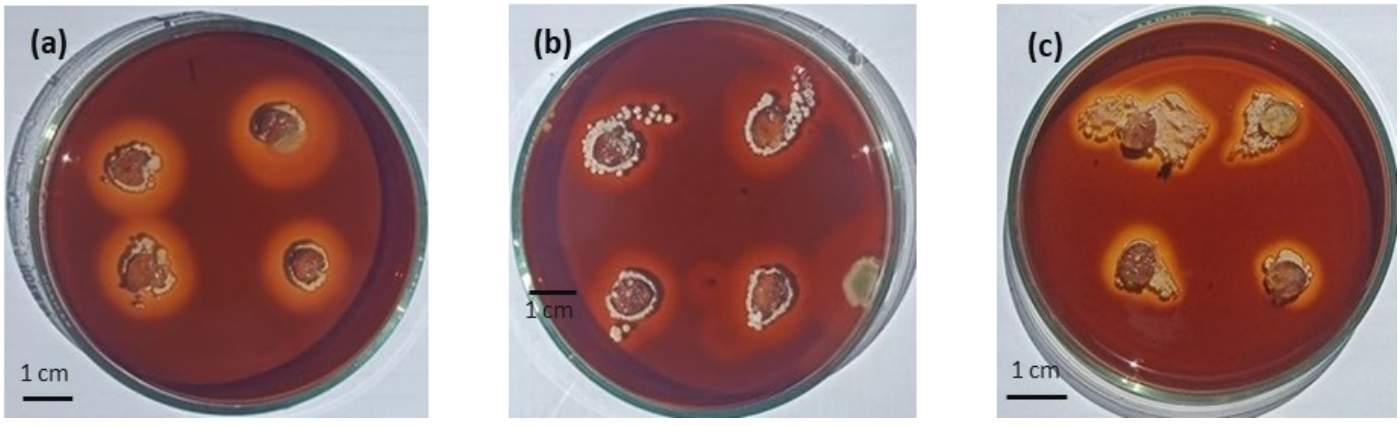

Figure 1. The clear zone around the actinomycetes colonies is an indicator of the activity of cellulolytic enzymes. (a) ASR 45 isolate; (b) ASR 67 isolate; (c) ASR 69 isolate.

can produce cellulase like *Streptomyces albogriseolus, Streptomyces lividans*, *Cellulomonas fimi, Microbispora bispora*, and *Thermobifida fusca* (Saini et al. 2015), as well as hemicellulase in *Streptomyces* spp. (Boroujeni et al. 2012).

Physical and chemical parameters as a quality indicator of coffee pulp compost

The physical parameters of compost, including temperature, pH, smell, color, and texture were measured after 21 days of incubation (Table 3). The results showed that the temperature of compost decreased continuously after 7 days of incubation in all treatments. According to (Lucitawati et al. 2018) the decreasing of compost temperature at the end of the composting period is due to the reduction of nutrient availability. (Wahyono 2011) also mentioned that increasing of compost temperature is caused by a high level of microbial activity during the composting process. The temperature range of all composting treatments was 29°C to 47°C which is appropriate with optimum temperature for composting process i.e. 27°C - 60°C (Chinakwe et al. 2019). The compost pH tends to increase until 21 days of incubation with a pH value of 8.3 to 8.7. From the research conducted by (Huang et al. 2004) the increase of compost pH occurred due to the production of ammonia through the ammonification process and mineralization of organic nitrogen by microorganisms. The odor parameters showed that the compost product from EM4 treatment (P1), cellulolytic actinomycetes treatment (P2), and zeolite treatment (P3) have more intense smell than compost product from the combination strarter of cellulolytic actinomyecetes and zeolite treatment (P4). Meanwhile, the color of compost in all treatments were darker along the incubation period. These change indicate the high temperature during the composting (Ilvo et al. 2020). The compost texture also tends to be more delicate during 21-days of incubation, except the compost resulted from EM4 treatment (P1) which becomes rougher at 21 days of incubation. The darker color of compost indicates high humus content that is beneficial to reduce the absorption of high solar energy and temperature fluctuations of soil if applied to the plant (Setyorini 2006).

The organic nutrient (N, P, K, C) and moisture content of compost during incubation are displayed in Table 4. According to the nutrient analysis results, nitrogen (N) content in compost from cellulolytic actinomycetes composted (P2) and EM4 composted (P1) treatments tend to increase up to 25 mg/kg and 24.6 mg/kg respectively on the fourth week. The increase of nitrogen levels in P1 and P2 treatments was due to an excretion process by microorganisms were in P1 and P2 inoculums, there were microbes which were capable of converting ammonia to nitrate by nitrifying bacteria at the end of the fermentation process. In addition, the presence of microorganisms also contributed to some single-cell proteins obtained during fermentation, after the decomposition process, nitrogen was released back as one of the components contained in fertilizers (Sundari et al. 2014). On the other hand, the addition of zeolite 5% (w/w) (P3) and the combination of

Table 3. Physical parameters of compost after 21 days of the incubation period.

No	Treatment	Incubation Time			
		0 day	7 days	14 days	21 days
		Temperature (°C)			
1	P1	31	47	39.5	35
2	P2	29	41	35	35.5
3	P3	29	43.5	38.5	34
4	P4	29	46	35.5	36
		pH			
1	P1	5.3	6.4	7.45	8.32
2	P2	6.9	8.4	8.35	8.38
3	P3	6.5	7.5	8.45	8.52
4	P4	6.9	7.8	8.65	8.71
		odor	**odor**	**odor**	**odor**
1	P1	+	++	++	+
2	P2	+	++++	++++	++++
3	P3	+	+++	+++	+++
4	P4	+	+	+	++
		color	**color**	**color**	**color**
1	P1	*	*	*	***
2	P2	*	**	**	**
3	P3	*	****	****	****
4	P4	*	***	***	**
		Texture	**Texture**	**Texture**	**Texture**
1	P1	+	++	+	+
2	P2	+	++++	++++	++++
3	P3	+	+	++++	++++
4	P4	+	+++	+++	+++

Notes:

P1 = EM4 5% (v/w)

P2 = Cellulolytic actinomycetes (*Streptomyces* spp.) 5% (v/w)

P3 = Zeolit 5% (w/w)

P4 = Cellulolytic actinomycetes 2.5% (v/w) +Zeolit 2.5% (w/w)

Odor

\+ = no odor

++ = smelly

+++ = strong smell

++++ = very strong smell

Color

* = light brown

** = brown

*** = dark brown

**** = black

Texture

\+ = rough

++ = rather rough

+++ = tender

++++ = delicate

cellulolytic actinomycetes 2.5 % (v/w) and zeolite 2.5% (w/w) (P4) treatments show that the nitrogen content was reduced during the 4-week incubation period. This may have occurred in the evaporation of nitrogen into the atmosphere, in addition to the presence of zeolite molecules that absorb ammonium ions to the surface of the zeolite and are tightly bound, then slowly released into the environment and to the plants (Soudejani et al. 2019). The organic carbon of compost sample was decreased during the 4 week incubation period in P1 and P2. The decrease of organic carbon was caused by the reduction of available carbon sources to the synthesis reaction

Table 4. Results of the analysis of the parameters of organic N, P, K, C, and moisture content of coffee pulp compost.

No	Treatment	Chemical Parameters					
		N (mg/kg)	P (mg/kg)	K (mg/kg)	C organic (mg/kg)	Water content (%)	C/N ratio
1	P1M1	16.62	5.10	25.70	438.65	0.122	26.39
2	P1M2	17.87	1.90	14.52	403.79	0.122	22.59
3	P1M3	19.37	4.77	23.77	401.80	0.009	20.74
4	P1M4	24.60	7.05	32.66	370.50	0.059	15.41
5	P2M1	14.09	4.67	17.37	438.65	2.41	31.13
6	P2M2	26.09	4.93	27.52	400.75	2.09	15.36
7	P2M3	21.39	8.90	27.25	397.52	3.03	18.58
8	P2M4	25.00	7.05	33.00	387.70	1.31	15.50
9	P3M1	22.00	5.50	22.48	283.66	2.61	12.89
10	P3M2	21.14	5.46	20.06	305.73	2.36	14.46
11	P3M3	14.75	5.49	18.68	297.60	0.77	20.17
12	P3M4	4.42	5.91	15.93	307.58	1.03	69.58
13	P4M1	29.46	3.76	12.30	325.54	2.52	11.05
14	P4M2	25.36	7.80	18.92	326.47	2.13	12.87
15	P4M3	22.06	6.67	20.25	314.88	1.26	14.27
16	P4M4	10.26	6.74	33.56	363.17	1.02	35.39

Note:

P1 = EM4 5% (v/w)

P2 = Cellulolytic actinomycetes (*Streptomyces* spp.) 5% (v/w)

P3 = Zeolit 5%

P4 = Cellulolytic actinomycetes (*Streptomyces* spp.) 5% (v/w) + Zeolit 5%

M1 = time incubation 1st week

M2 = time incubation 2nd week

M3 = time incubation 3rd week

M4 = time incubation 4th week

of the new complex and polymerized organic compounds (humification) during the maturation phase (Bernal et al. 2009). Other posibilities can also causethe loss of carbon in the form of CO_2 during the decomposition process (Getahun et al. 2012). While in the P3 and P4 treatments, the organic C content fluctuated. The coffee pulp which contains mostly of fiber is great carbon source for actinomycetes. This is corresponding to Khatoon et al. (2017) which stated that the availability of carbon sources in the decomposition process is very important to provide energy for microorganisms to grow optimally. The initial C/N ratio of coffee pulp composition in P1 and P2 treatment complied with the requirement of organic material to be composted according to the Indonesian National Standard (SNI 19-7030-2004) of mature compost i.e. 10-20. The initial C/N ratio will affect the rate of composting process by microorganisms including cellulolytic actinomycetes which inoculated in the coffee pulp. When the initial C/N ratio exceeds approximately 30, the composting process will occur longer. Otherwise, if the initial C/N ratio is too low, the nitrogen will volatilize along the composting process (Amalia 2016). Surtinah (2013) stated that the C/N ratio of compost indicated the maturity rate of compost, the higher

C/N ratio of compost showed that compost has not decomposed completely. In addition, the final C/N ratio of compost which is lower than 20 indicated that nutrient contained in organic waste has been degraded and mineralized into available nutrient for plant (Hanafiah 2005).

The phosphorus (P) content in compost from all treatments showed an increase on the fourth week of incubation. The highest increase in phosphorus and potassium (K) content after 4 weeks of incubation was seen in coffee pulp compost with the actinomycete inoculum (P2) which were 7.05 mg/kg and 33.0 mg/kg, respectively. In addition, the potassium (K) content in compost from P1and P4 treatments also increased. Meanwhile, the moisture content which indicates the quantity of water is contained in the compost decreased in all treatments. Generally, the phosphorus and potassium content as well as the water content in compost, also meet the Indonesian National Standard (SNI 19-7030-2004) of nutrient content in compost. The phosphorus and potassium elements in P_2O_5 and K_2O are macronutrients in which their amount was determined by the compost material (Amalia 2016). Besides the final C/N ratio, the P and K content in compost also indicated that actinomycetes are able to transform coffee pulp-containing fiber into organic matter effectively due to their ability to produce cellulolytic enzymes (Saini et al. 2015).

Effect of compost on the growth of chili plants in the greenhouses

Compost has an important role in plant growth and development due to its nutrient content and potency to increase the soil physicochemical properties. As an organic fertilizer, compost provides nutrient that can be used directly by the plant. To determine the effect of coffee pulp compost on chili plant, we cultivated the chili plant on modification growing media in the greenhouse. The growing media for chili plants consisted of soil, coffee pulp compost, and sand with a ratio 2: 1: 1, respectively. The growth parameters of chili plants such as the stem height, the number of leaves, and dry biomass were measured each week a long four weeks of cultivation.

The length of stem, the number of leaves, and biomass of chili plants treated with coffee pulp compost grew better than chili plants without coffee pulp compost. The highest stem height and number of leaves are generated from chili plants with coffee pulp composted by 5% zeolite treatment (Figure 2). The length of stem of chili plant treated with coffee pulp compost added with zeolite was higher than untreated plant. Zeolite is an aluminum silica crystal flake that is hollow in it and has metal ions, usually alkaline or alkaline earth, and can move freely (Kurniasih et al. 2017). Zeolite is widely used in agricultural land and functioned as a soil repairer to improve soil cation-excange capacity (CEC) and pH value in acidic soils as well as increase the soil's ability to absorb and to release water and nutrients slowly (Widyanto et al. 2013). Zeolites can also improve soil aggregation thereby increasing soil pores which stimulate plant root growth.

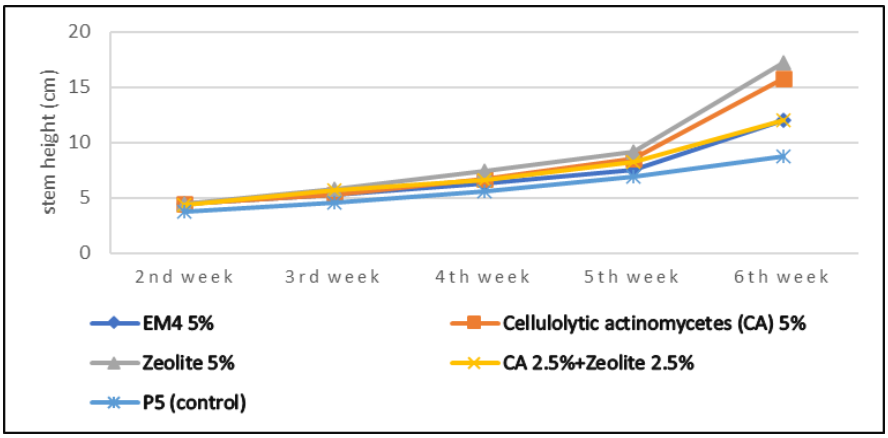

Figure 2. Stem height of chili plants treated with various coffee pulp compost.

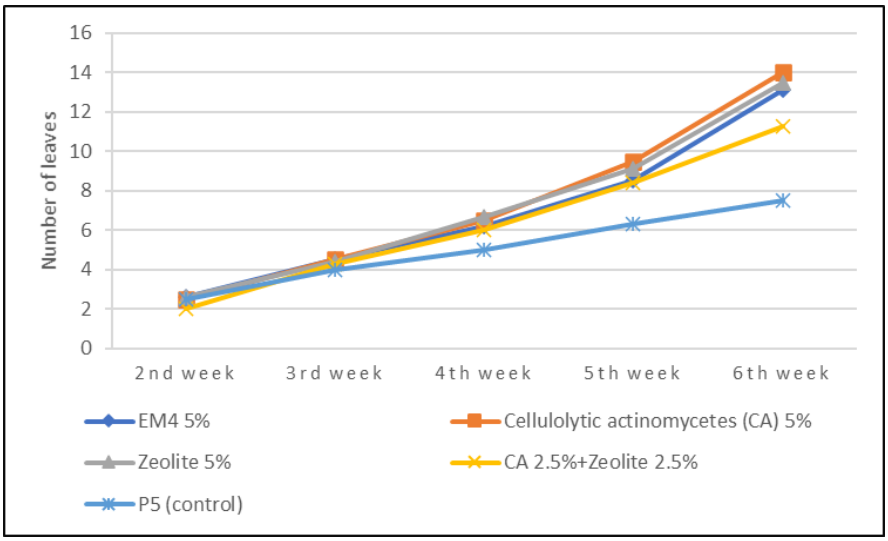

Figure 3. Number of leaves of chili plants treated with various coffee pulp compost.

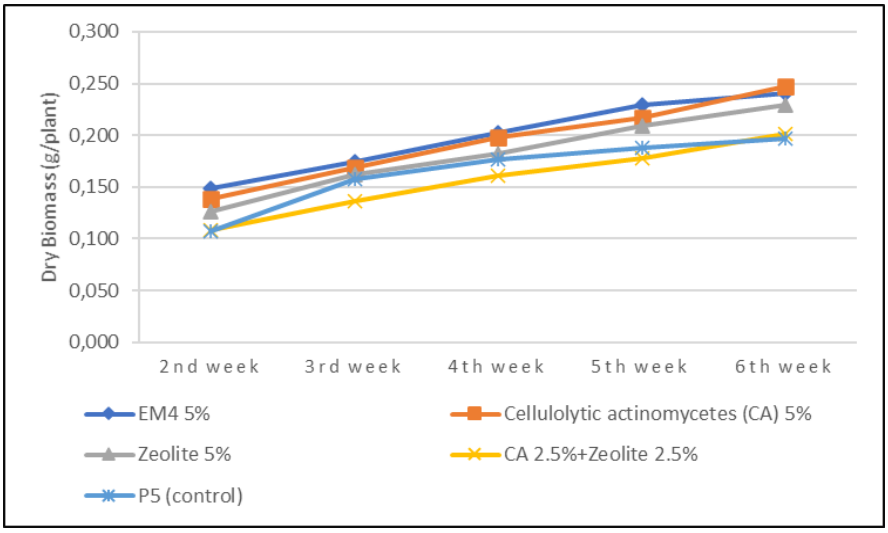

Figure 4. Biomass of chili plants treated with various coffee pulp compost.

The coffee pulp compost treatment also positively affects the number of chili leaves compared to the control treatment (Figure 3). The chili plant with coffee pulp composted by cellulolytic actinomycetes resulted the highest number of leaves i.e. 13.1 ± 2.8, increased by 96% compared to the control.

While the highest biomass was plant treated by amending compost by cellulolytic actinomycetes starter increased by 25% compared to the control (Figure 4). In this study, actinomycetes involved in the degradation of coffee pulp into compost which is rich in organic matter that can be used directly by the chili plant. In addition, the existence of cellulolytic actinomycetes in coffee pulp compost also increases the growth of the chili plant due to its role as plant growth promoter bacteria. As previously mentioned, cellulolytic actinomycetes isolate used in this research are capable to dissolve phosphate, providing nitrogen, and producing IAA- phytohormones (Fatmawati et al. 2019). Actinomycetes are Gram-positive bacteria that have a mycelium-shaped morphology that is commonly found in soil. The provision of actinomycetes culture to increase plant growth has been widely studied, including maize (Wahyudi et al. 2019); tomatoes (El-Tarabily 2008); wheat (Sadeghi et al. 2012), rice (Gopalakrishnan et al. 2013). Actinomycetes directly play an important role as plant growth-promoting rhizobacteria (PGPR) by producing phytohormones, nitrogen fixers, phosphate solvents, and siderophore production (Khamna et al. 2010).

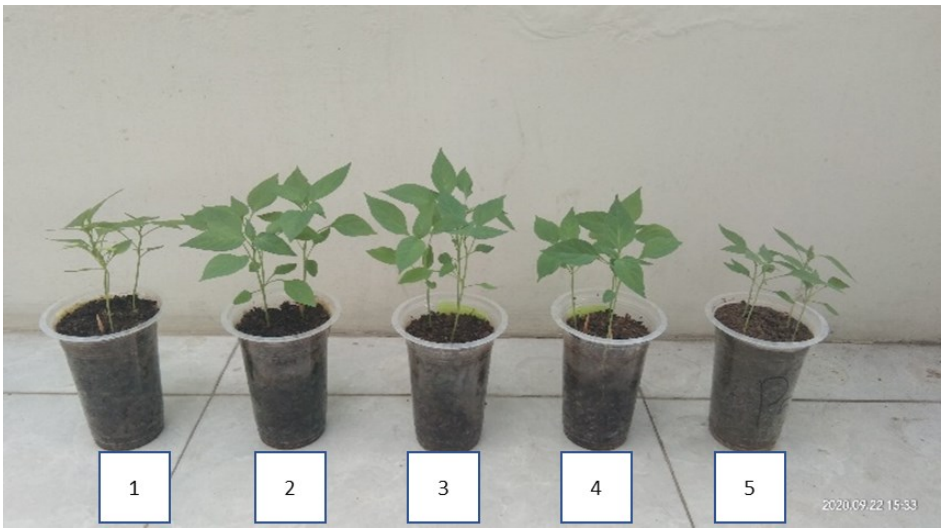

Figure 5. The growth of chili plants in the treatment of the planting medium with coffee pulp compost in a greenhouse. (1) EM4 5%; (2) 5% cellulolytic actinomycetes; (3) zeolite 5%; (4) 2.5% cellulolytic actinomycetes and 2.5% zeolite, and (5) soil without the addition of compost.

According to this study, the addition of coffee pulp compost that was decomposed using cellulolytic actinomycetes starter was proven to increase the growth of chili plants in the greenhouse (Figure 5). Furthermore, the coffee pulp compost is potentially applicable to other horticultural crops in the field and can substitute the use of chemical fertilizer in the future. Coffee pulp compost can be used as a soil conditioner to increase soil organic matter content, thereby increasing soil fertility. Good compost must meet the following requirements: contains slow-release nutrients and improves soil fertility. The existence of compost can alter the loose soil texture as a result of the decomposer microorganisms' activity as well as soil microbial myceli-

um which functions as soil particle adhesive. This is also related to the presence of actinomycetes in the compost where their mycelium can serve as soil particle adhesive and improve soil aggregates which create appropriate soil area for plants (Setyorini 2006). Application of compost to the soil will also increase the population of beneficial microbes in the soil, as well as suppress several types of soil pathogenic microbes (Bonanomi et al. 2020). The addition of organic compost can control soil borne pathogen directly by producing the fungitoxic compound (Blok et al. 2000) or indirectly enhancing the suppresive microbiome by the competition of space and nutrient (Hoitink & Boehm 1999), direct parasitism (Bonilla et al. 2012), and antibiosis (Raaijmakers & Mazzola 2012).

CONCLUSION

According to this research, seven selected cellulolytic actinomycetes isolates have hydrolytic activity toward coffee pulp waste based on *in vitro* assay and proven to be effective in the coffee pulp composting process. This result indicated that the actinomycetes have the potency to be utilized as a composter agent of coffee processing waste to generate a good quality of coffee waste compost. Coffee pulp composted with cellulolytic actinomycetes showed the best result in nutrient content parameters especially in nitrogen content (25 mg/kg), P (7.05 mg/kg), K (33.0 mg.kg) as well as the delicate texture in the physical parameter during the four week incubation. The coffee pulp compost resulting from cellulolytic actinomycetes is also effective to increase the growth of chili plants in greenhouse experiments. The treatment of coffee pulp compost resulting from cellulolytic actinomycetes and zeolite showed the equivalent effect to the height of the chili plant. However, the highest number of chili leaves and the plant biomass were resulted from the coffee pulp compost resulting from cellulolytic actinomycetes Furthermore, it is necessary to prove the effect of coffee pulp compost on other horticultural crops in greenhouse and field experiments.

AUTHORS CONTRIBUTION

UF was responsible for planning and conducting the research, collecting, analyzing the data, and writing the manuscript. DPS was responsible for conducting the research and interpreting the data. MI collected and interpreted the data. SS was responsible for providing the material and interpreting the data. H was responsible for conducting the research and interpreting the data. SMW was responsible for designing the methodology and writing the manuscript

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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