Available online at:
http://journal.unila.ac.id/index.php/tropicalsoil
DOI: 10.5400/jts.2022.v27i2.89-98

Soil Organisms Activities in Red Onion Cultivation with Application of Plant Extract Suspension and Compost

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Received 23 December 2021; Revised 29 April 2022; Accepted 19 May 2022

ABSTRACT

Agro-industrial waste such as banana weevil, pineapple rhizome, and empty fruit bunches of oil palm has not been utilized properly, even though the waste can be processed into liquid organic fertilizer after extracting the beneficial microorganisms contained in it. This research aimed to observe and study soil organisms' activity after applying plant extract suspensions and compost types. The research was conducted at the Integrated Field Laboratory and Soil Science Laboratory, Faculty of Agriculture, University of Lampung. The treatments were designed in a 3 × 3 factorial design in a Randomized Block Design with three replications. The first factor was the plant suspension extracts derived from banana weevil, pineapple rhizome, and oil palm empty fruit bunches, while the second factor was the compost in the form of solid compost and liquid compost. The results showed the activity of soil organisms in the form of respiration, soil microbial carbon biomass, soil microbial population, and mesofauna population, which was applied to a suspension of plant extracts from pineapple rhizome, given the highest yield. Furthermore, the bacterial phosphate dissolution index and the diversity of soil mesofauna applied to liquid compost were higher than those of solid compost or without compost. There was no interaction between the application of plant extract suspension and the compost types on the soil organism's activity.

Keywords: Compost, mesofauna, plant extract suspension, soil microbial abundance, soil organism activity

INTRODUCTION

The increase production of oil palm, pineapple, and banana plantation creates a waste problem. Palm oil production in 2016 reached 33,229 thousand tons, likewise with pineapple plantations, whose production reached 1,558 thousand tons in 2009 (BPS 2016). An increase in the amount of production causes more waste to be generated. The waste from the plantations has not been utilized properly, even though the waste can be processed into liquid organic fertilizer after extracting the beneficial microorganisms contained in it. Oil palm empty fruit bunches (EFB), pineapple rhizomes, and banana weevil contain macro and micronutrients, microbial decomposers, and growth regulators needed by plants. The results of the study by Dermiyati *et al.* (2019; 2020a) showed that pineapple rhizome and EFB waste contained microorganisms with various characteristics. Lestari *et al.* (2019) also reported that suspension of plant extracts from banana weevil could increase onion growth and production depending on the frequency of application. Research Soelaksini *et al.* (2018) showed that suspension of plant extracts from banana weevil could increase the number of branches in soybean plants, while so far, there is no information on the effect of suspensions of plant extracts from pineapple rhizomes. In addition, livestock manure such as goats, chickens, and cows combined with plantation waste can also be used as compost. Compost is perfect for supplying soil organic matter and nutrients (Barus 2016), increasing cation exchange capacity, increasing the ability of the soil to store water and other soil physical properties (Adamtey *et al.* 2010), and increasing the activity of soil organisms (Arslan *et al.* 2010); Saison *et al.* 2006; Sizmur *et al.* 2011; Schulz *et al.* 2013).

The use of organic fertilizers, such as compost and suspension of plant extracts containing local microorganisms, can increase soil fertility. The application of organic fertilizer in compost is reported to increase soil organic matter content (Adani *et al.* 2007; Soumare *et al.* 2003), infiltration, and water retention (Agassi *et al.* 2004). Compost also increases the concentration of available water in the root zone and increases crop yields (Agassi *et al.* 2004). Local microorganisms derived from plant extracts can improve soil conditions, increase plant growth (Soelaksini *et al*. 2018), increase plant root resistance in leaves and stems, affect the process of photosynthesis, destroy and decompose organic matter in the soil, decompose complex organic compounds such as carcasses of animals and plants into nutrients so that they can be absorbed by plants (Hadi 2019).

One of the factors that can affect soil fertility is the presence of phosphate solubilizing microorganisms (PSM). Phosphate solubilizing microbes can secrete organic acids such as citric acid, oxalic acid, and succinic acid, as well as several enzymes such as phytases and chelating ions such as siderophores that easily make phosphorus available to plants (Tomer *et al.* 2016). Soil fertility can also be seen from the soil microbial activity, such as respiration and soil microbial carbon biomass, as well as the abundance of several vital organisms, such as the abundance of microbes in the soil phosphate solubilizing microbes, and soil mesofauna.

Mesofauna act as early decomposers for soil organic matter. Without soil mesofauna, the decomposition process cannot run properly. Although most of the decomposition of organic matter is carried out by soil microorganisms, the soil mesofauna significantly affects the rate of decomposition and activity of soil microorganisms (Frouz 2018). In addition, indicators of soil fertility can also be seen from the abundance of soil mesofauna both in number and diversity. Information regarding the effect of plant extracts suspensions, their interactions with compost fertilizers on the performance of shallots, changes in microbial activity, and changes in the abundance of soil organisms are still minimal. Therefore, this study aimed to study the effect of applying suspension types of plant extracts and compost and the interaction between them on soil microbial activity, microbial abundance, and soil mesofauna in shallot plantations.

MATERIALS AND METHODS

This research was conducted at the Integrated Field Laboratory and Soil Science Laboratory, Faculty of Agriculture, University of Lampung. The treatments were designed in a 3 × 3 factorial design in a Randomized Block Design with three replications. The first factor was the suspension type of plant extracts derived from banana weevil, pineapple rhizome, and empty fruit bunches of oil palm, while the second factor was the type of compost, namely without solid and liquid compost. The data were analyzed through variance, and the difference in the mean of treatment was tested using the *Duncan Multiple Range Test* (DMRT) at the 5% level.

Plant Extract Suspension Manufacturing

The suspension of plant extracts was prepared according to the procedure of Dermiyati *et al.* (2020b) as many as 1.5 kg each of banana hump, pineapple rhizome, and EFB chopped into smaller pieces, then each plant material was added with 250 g of brown sugar which has been finely chopped and then dissolved with 3 L of rice washing water and 3 L of coconut water. Then put it in a 10 L bucket. The bucket was tightly closed with a small air hole connected to a hose containing water in a 1L bottle. The material was fermented for 21 days; the solution was then filtered and stored in a storage container.

Composting

The materials for composting were cow dung (300 kg), laying hens (25 kg), laying broilers (25 kg), rice straw (150 kg), and EFB. Compost was made in layers. In each layer, the bottom layer was filled sequentially with rice straw, layer chicken manure, broilers, EFB, and cow manure at the top. The materials were then sprinkled with 200 g of urea and 800 g of dolomite and then doused with 1 L solution of N fixer and P solvent and 5 L of EM4 and sugar solution per layer. Maintenance carried out included watering and turning and watering the compost when the compost condition started to dry and was turned once a week for eight weeks. The final result was solid compost. Liquid compost was made by extracting as much as 1 kg of solid compost, adding 50 g of granulated sugar and 5 L of water, and extracting for 48 hours using an aerator. The solution was then filtered to extract the compost.

Isolation of Bacteria from Plant Extracts and Soil Suspensions

The technique of microbial isolation from soil was carried out using the *Platting Method dilution method* (Pelczar and Chan 2006), namely by weighing 10 g of soil and then putting it into an Erlenmeyer containing 90 mL of physiological solution and shaken until homogeneous.

Isolation was done by using the *Pour Plate method*. Each diluent factor was taken aseptically as much as 1 mL, then poured into an empty sterile petri dish, then the growth medium was poured into a petri dish that already contained the sample. Petri dishes containing samples and growing media were homogenized and incubated for 24-72 hours at 37ºC. The same method was also used to isolate microbes from suspensions of plant extracts.

Testing of Bacterial Isolates as Phosphate Solvents

Bacterial testing as a phosphate solvent was carried out using Pikovskaya media. The purified bacterial isolates were then inscribed into the Pikovskaya medium using an ose needle. Furthermore, it was incubated for 24 hours and observed for the clear zone formed around the colony from 1 to 7 days after planting the sample.

Measurement of Soil Respiration and Soil Microbial Biomass Carbon

Soil respiration measurements were carried out using a modified Verstraete method (Anas 1989) and soil microbial biomass carbon (C-mic) using the Fumigation-Incubation method (Jenkinson and Powlson 1976), which has been refined by Franzluebbers *et al.* (1999). The analysis was carried out to determine the amount of CO_2 bound by the KOH solution determined by titration.

Calculating of Soil Mesofauna Population

Soil mesofauna population calculation was done by separating mesofauna from litter or soil using *Tullgren Barlese*, equipped with a filter and 25-watt lamp. The funnel was filled with 25 mL (60%) alcohol solution; the lamp was turned on for 48 hours while the process was running. Mesofauna accommodated in alcohol was observed and identified based on the order, each order, and the total number of orders (Borror *et al.* 1992).

RESULTS AND DISCUSSION

Effect Application of Plant Extract Suspension and Compost Type on Soil Microbial Abundance

Bacterial Population in Plant Extract Suspension

The increase in bacterial population in the suspension of plant extracts can be seen in Figure 1. Suspension of plant extracts from banana weevil produced the highest bacterial population of 13×10^5 CFU mL^{-1} or as much as 6.12 Log CFU mL^{-1}. The lowest bacterial population was found in the suspension treatment of plant extracts from EFB, namely 8×10^5 CFU mL^{-1} or as much as 5.91 Log CFU mL^{-1}.

Bacterial colonies in the suspension of plant extract from pineapple rhizome, oil palm empty bunches, and banana weevil are shown in Figure 2.

Bacterial Population in Soil Suspensions

The increase in the population of soil bacteria due to the application of of plant extracts suspension can be seen in Figure 3. Application of plant extracts suspension from pineapple rhizome gave the highest bacterial population yield of 12×10^5 CFU g^{-1} soil or 6.11 Log CFU g^{-1} soil. The lowest population was

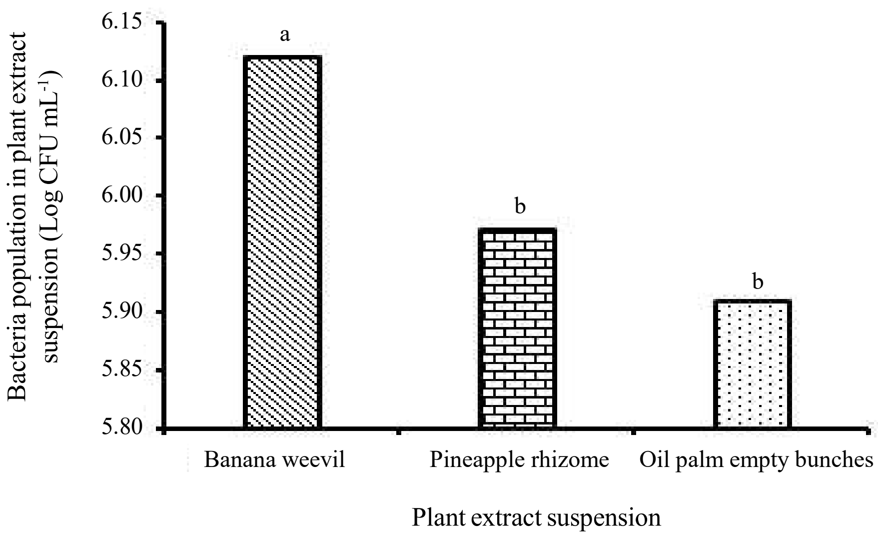
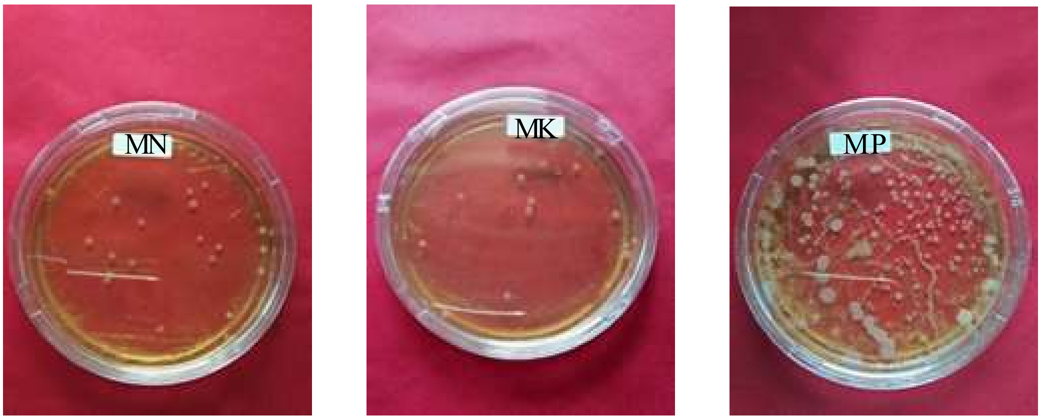


Figure 1. Total of bacteria population in plant extract suspension. The same letter on the bar shows no significant difference based on the DMRT test at the 5% level.



(A) (B) (C)

Figure 2. Bacterial colonies in the suspension of plant extract from pineapple rhizome (A), oil palm empty bunches (B), and banana weevil (C).

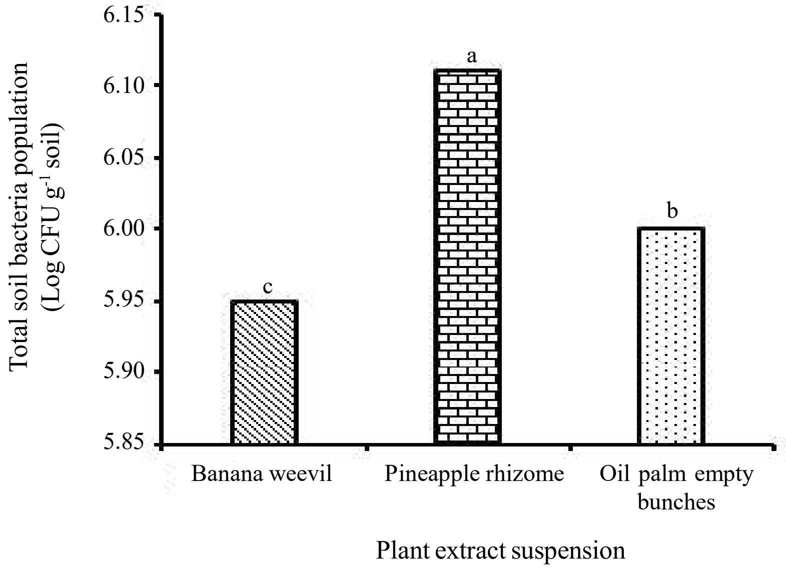


Figure 3. Bacteria population in the soil-applied with plant extract suspension. The same letter on the bar shows no significant difference based on the DMRT test at the 5% level.

obtained in the suspension treatment of plant extracts from banana weevil at 8.9×10^5 CFU g^{-1} soil or 5.95 Log CFU g^{-1} soil.

Soil bacterial population isolated from soils that has been applied by suspension extracts from pineapple rhizome and banana weevil can be seen in Figure 4.

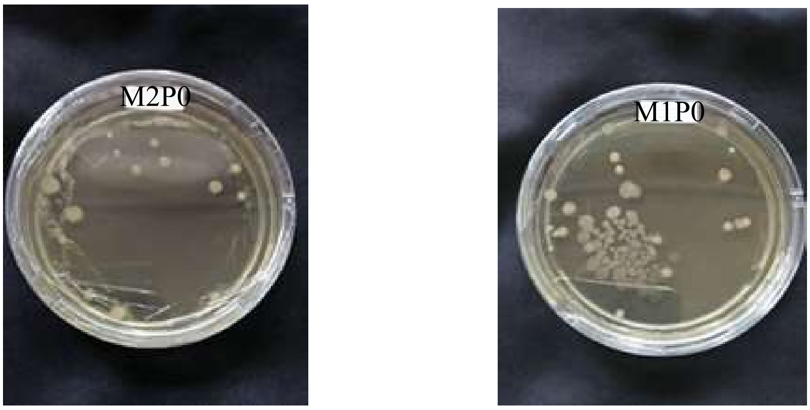
The Ability of Bacteria to Dissolve Phosphates

Suspension of plant extracts from pineapple rhizome gave the highest bacterial phosphate solubilization index yield compared to suspensions of plant extracts from banana weevil and EFB. The same thing was also happened to the suspension of plant extracts that had not been applied to the soil, where the most extensive phosphate solubilization index was also obtained in the suspension treatment of plant extracts from pineapple rhizome. In contrast, the lowest phosphate dissolution index was obtained in the suspension treatment of plant extracts from banana weevil (Table 1).

Bacterial colonies with the clear zone and without clear zone which show the ability of bacteria to disslove phosphate are shown in Figure 5.

Soil Mesofauna Population

The increase in the population of soil mesofauna due to the suspension of plant extracts can be seen in Table 2. Suspension of plant extracts from pineapple rhizome gave the highest yield on the total



(A) (B)

Figure 4. Soil bacterial population isolated from soil that has been applied by plant extract suspension; suspension extracts from pineapple rhizome (A); suspension extract from banana weevil (B).

Table 1. Bacterial Phosphate Dissolution Index in Soil and Plant Extract Suspensions.

Plant Extract Suspension Treatment	Phosphate Solubility Index(cm)	
	Soil	Plant Extract Suspension
Banana Weevil	0.29 b	1.86 b
Pineapple Rhizome	4.74 a	3.97 a
Oil Palm Empty Bunches	1.93 b	3.22 a

Note: The numbers followed by the same letter in the same column are not significantly different in the 5% DMRT Test.

(A) (B)

Figure 5. Bacterial colonies with the clear zone (A); Bacterial colonies without clear zone (B).

Table 2. Effect of Plant Extract Suspension Application on Total Soil Mesofauna Population.

Plant Extract Suspension Treatment	Population (tail dm^{-3})
Banana Weevil	35 b
Pineapple Rhizome	66 a
Oil Palm Empty Bunches	56 a

Note: The numbers followed by the same letter in the same column show that they are not significantly different in the 5% *Duncan Multiple Range Test* (DMRT).

population of soil mesofauna as much as 66 dm^{-3}, while the lowest total population of mesofauna was in the suspension of plant extracts from banana weevil which were only 35 dm^{-3}.

Mesofauna Dominance Index

The soil mesofauna dominance index due to the suspension of plant extracts can be seen in Figure 6. The suspension treatment of plant extracts from pineapple rhizome resulted in the highest mesofauna dominance index compared to suspension treatments of plant extracts from banana weevil and EFB.

Mesofauna Diversity Index

Suspension treatment of plant extracts from pineapple rhizomeresulted in the highest mesofauna diversity index compared to the suspension treatment of plant extracts from banana weevil, although it was not significantly different from the EFB treatment. In the compost treatment, the mesofauna diversity index in the liquid fertilizer treatment was higher than in the solid fertilizer treatment and without fertilizer (Table 3).

The types of mesofauna found in the research area were grouped into four orders, namely Acarina, Collembola, Sympilla, and Diplura (Figure 7).

Effect of Plant Suspension Extracts and Compost Applicationon on Respiration and Soil Microbial Biomass Carbon

The increase in respiration and soil microbial carbon biomass due to the suspension of plant extracts can be seen in Figure 8. Suspension treatment of plant extracts from pineapple rhizome produced the highest respiration and soil microbial carbon biomass compared to suspension treatment of plant extracts from banana weevil and EFB.

Discussion

The population of bacteria in each suspension of plant extracts varied (Figure 1). However, suspension of plant extracts from banana weevil

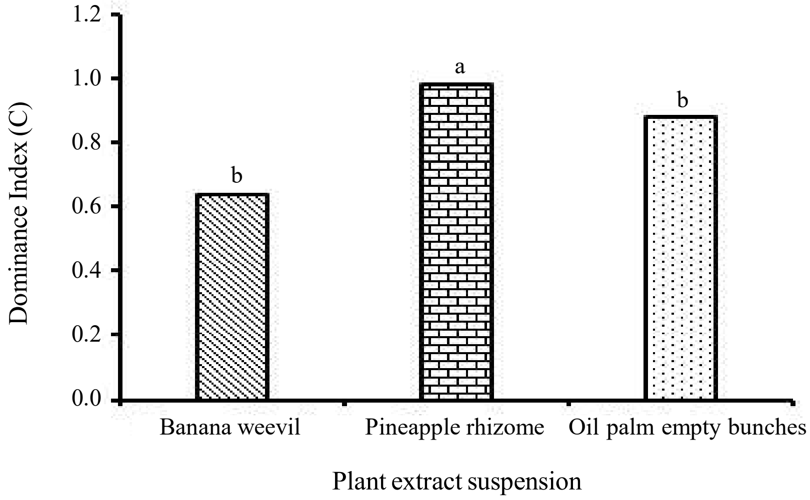


Figure 6. Mesofauna dominance index in soil with plant extract suspension. The same letter on the bar shows no significant difference based on the DMRT test at the 5% level.

Table 3. Mesofauna diversity index of soil suspension treatment of plant extracts and compost on onion growing media.

Treatment	Diversity index (H')
Plant Extract Suspension	
Banana Weevil	0.64 b
Pineapple Rhizome	0.88 a
Oil Palm Empty Bunches	0.98 a
Compost	
Without Compost	0.69 b
Solid Compost	0.80 b
Liquid Compost	1.02 a

Note: The numbers followed by the same letter in the same column show no significant difference in the 5% DMRT test.

Figure 7. Orders (A) Acarina, (B) Collembola), (C) Sympila), (D) Diplura. (Observation by 40x magnification binocular microscope).

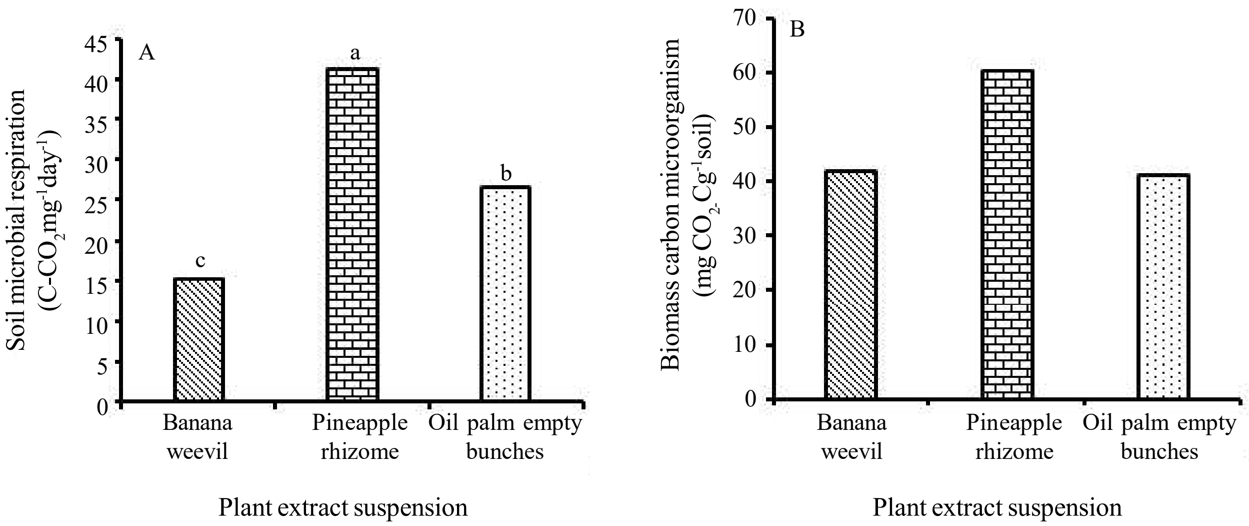


Figure 8. Improvement of soil microbial respiration (A); soil microbial carbon biomass (B) application of plant extract suspension. The same letter on the bar shows no significant difference based on the DMRT test at the 5% level.

produced the highest bacterial population compared to suspensions of plant extracts from pineapple rhizomes and EFB. However, when applied to plants, the bacterial population in the suspension of plant extracts from banana weevil decreased and became the lowest compared to plant extracts from pineapple rhizomes and EFB. Because the bacteria contained in the banana weevil cannot dissolve phosphate, which has been proven by testing the ability to dissolve phosphate by bacteria, they are unable to dissolve bound phosphate into a form that are available to plants. The suspension treatment of plant extracts from pineapple rhizome showed the highest bacterial population when applied to plants (Figure 3). The study results also strengthen these results by Dermiyati *et al.* (2019), who reported that the number of bacterial populations obtained under various conditions of making liquid organic fertilizer in suspensions of plant extracts from pineapple rhizomes was higher than suspensions of plant extracts from EFB. In addition, it is also suspected that the pineapple rhizome used for the manufacture of plant extract suspensions is located close to the plant roots, making it contain many beneficial microbes. This is also reinforced by Sari (2020), who reported that the results of bacterial isolation from suspensions from pineapple rhizomes contained the bacterium *Stenotrophomonas maltophilia. S. maltophilia* bacteria are often found in the rhizosphere (Page *et al*. 2008). *S. maltophilia* will associate with plants and have a strong ability to form biofilms (An and Berg 2018). The biofilm formed on the roots will protect the plant from infection caused by pathogens (Bais *et al.* 2004). In addition, the area around plant roots is an area that is very rich in nutrients that can be used as microorganisms as their primary habitat in carrying out their metabolic processes (Mommer *et al.* 2016; Philippot *et al.* 2013), so that when applied to plants, there will be a good interaction between plants and microbes in the rhizosphere area. The interactions between organisms are essential for the proper functioning of the agroecosystem.

The rhizosphere contains root exudates in organic acids and other chemical compounds released by plants. Niswati *et al.* (2009) revealed that the population and diversity of microorganisms were thought to be influenced by the exudate released by plant roots. Root exudates affect the formation of populations of microorganisms in the rhizosphere (Badri and Vivanco 2009), where these root exudates secrete metabolites such as amino acids, organic acids such as citric and malic acid, and secondary plant compounds such as flavonoids and terpenoids (Bais *et al.* 2008) and is the primary carbon source in the ecosystem (Yan and Johnson 2008). Root exudates also make up the root microbiome and play an essential role in recruiting and attracting beneficial soil bacteria to the rhizosphere. Several specific compounds in root exudates can act as signaling molecules to regulate the activity of microorganisms in the rhizosphere (Feng *et al.* 2019; Wang *et al.* 2019). Marshcner and Timonen (2006) also reported that microbial population density increased rapidly in the zone behind the root tip, where high concentrations of root exudates could be used for microbial growth and metabolism. This is a clear indication that plants strongly influence the microbial population in their roots (Miethling *et al.* 2000). The increase in the microbial population will affect the respiration and carbon biomass produced by microbes, where the higher the population, the greater the respiration and biomass produced.

Bacteria that have the ability to dissolve phosphate are evidenced by the formation of a clear zone on the *pikovskaya growing medium* as a sign of the activity of phosphate solubilizing bacteria and expressed in the phosphate solubilizing index (Teng *et al*. 2019). Suspension of plant extracts from pineapple rhizomes gave the highest phosphate solubilization index compared to suspensions of plant extracts from banana weevil and EFB. Dermiyati *et al.* (2019) reported that seven bacterial isolates derived from suspensions of plant extracts from EFB and four bacterial isolates from pineapple rhizomes had a very high ability to dissolve phosphate but bacterial isolates from suspensions from pineapple rhizomes had a higher phosphate solubilization index. They were compared to the suspension from EFB. The phosphate solubilization index produced by bacteria in each treatment was different. This is following the opinion of Satyaprakash *et al*. (2017), reported that the difference in the clear zone area produced by each bacterial isolate was caused by the ability of bacteria to produce different organic acids, where the organic acids affected the dissolution of P elements which Al, Fe still bound, and Ca into P elements which available to plants. The same thing was also stated by Van *et al.* (2005) that phosphate solubilizing microbes have the ability to dissolve different phosphate minerals through the secretion of organic acids and produce phosphatase enzymes capable of liberating P from organic P.

In general, the mesofauna dominance index in this study did not reach 1, so it was categorized as low. In this study, planting was only carried out in *polybags* using 5 kg soils, and only red onion was grown. The less extensive growing media allowed the land to be dominated by only one order. The order that dominates in this treatment is *Collembola*. Niswati *et al.* (2019) reported that the mesofauna dominance index in maize research land is low because it is only dominated by one order, namely *Acarina*. In this regard, this group of organisms is known to regulate and stabilize soils through complex network interactions, contributing to organic matter decomposition and nutrient cycling (Frouz 2018). The existence of *Collembola* is influenced by environmental conditions, especially soil nutrient content. The availability of soil nutrients is related to bacteria and fungi, which are one of the foods for *Collembola*. According to Zayadi *et al.* (2013), environmental factors such as soil moisture, C/N, and soil organic matter affect differences in the community structure of soil arthropods, such as *Collembola*.

The mesofauna diversity index in this study was also low, ranging from 0.64-0.98. A low diversity of mesofauna was likely due to the reduced availability of food sources for soil mesofauna because the addition of organic matter into the soil only up to 35 DAP. Brown (1978) stated that abundant food sources cause mesofauna diversity to increase. Niswati *et al.* (2010) also argue that the primary food source for soil mesofauna is organic matter. Low organic C causes the soil mesofauna to only get food from root exudates, which is insufficient for its growth. Likewise, the limited C source results in low soil mesofauna diversity.

CONCLUSIONS

Soil mesofauna population, soil respiration, and soil microbial biomass carbon on suspensions of plant extracts from pineapple rhizomes were higher than suspension of plant extracts from banana weevil and EFB. Bacterial phosphate dissolution index and soil mesofauna diversity on liquid compost were higher than those of solid compost or without compos. However, there was no interaction between the application of plant extract suspension and compost fertilizer on the activity of soil organisms.

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