Available online at:
http://journal.unila.ac.id/index.php/tropicalsoil
DOI: 10.5400/jts.2021.v26i3.149

Change of Soil Biomass Carbon Microorganism in Ultisols Soil Due to Application of Humic Acid and TSP Fertilization

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Received June 22, 2021; Revised September 28, 2021; Accepted 30 September 2021

ABSTRACT

Soil biomass carbon microorganism (C-mic) is one indicator of soil fertility. The application of humic acid, vermicompost aqueous extract, and TSP fertilization applied to the soil will affect the activity of soil microorganisms. This research aimed to study the effect of humic acid, vermicompost extract, and TSP fertilization on C-mic. The first factor was the application of humic acid (h), namely, without humic acid, commercial origin, and humic acid-like from watery extract vermicompost. The second factor is TSP fertilization (p) divided into four dose levels: without TSP fertilizer, TSP fertilizer 100 kg ha^{-1}, TSP fertilizer 200 kg ha^{-1}, and TSP fertilizer 300 kg ha^{-1}. Data were analyzed by analysis of variance and continued with the Least Significant Difference (LSD) test at the 5% significance level. The correlation between C-organic, soil pH, soil temperature, soil moisture content, stalk dry weight, and weight of corn kernels with C-mic was tested by correlation test. The results showed that the application of humic acid and TSP fertilization had no significant effect on C-mic, and there was no interaction between the two at seven days after planting (DAP), 56 DAP, and 104 DAP. There was a correlation between soil organic carbon 7 DAP (r: 0.34*), 56 DAP (r: 0.59*), and 104 DAP (r: 0.53*), soil moisture content at 7 DAP (r: 0.36*), soil pH at 56 DAP (r: 0.42*) and 104 DAP (r: 0.43*), soil temperature at 104 DAP (r: -0.52*), stalk dry weight at 56 DAP (r: 0.34*), corn kernels weight at 113 DAP (r: 0.65*) with C-mic.

Keywords: Humic acid, soil microorganism carbon biomass, vermicompost aqueous extract, TSP fertilization

INTRODUCTION

Ultisol mainly dominates soils in Indonesia. Ultisol soil has a low pH, low cation exchange capacity, low base saturation, low and unavailable nutrient content such as N, P, K, Ca, Mg, and high Al-Exchange levels, resulting in the unavailability of sufficient nutrients for plant growth (Subagyo *et al.* 2000). One of the obstacles in Ultisol soil for agricultural cultivation is the high Al solubility associated with soil acidity. The high solubility of Al causes P in the soil to be bound to the insoluble Al-P form, thereby reducing the availability of P for plants (Bates and Lynch 2001 cited by Wahyudi 2007).

The way to overcome problems in ultisol soil is by adding organic matter and fertilization to the soil. The addition of organic matter with high C/N can encourage the breeding of soil microorganisms. Thus, the addition of organic matter is expected to increase the activity of soil microorganisms (Riniarti *et al.* 2012). Soil enhancers are usually used to increase soil organic matter content. One of the soil amendments used is humic acid (commercial humic acid and humic acid-like from watery extract vermicompost).

Humic acid is a polyelectrolyte macromolecule consisting of functional groups such as -COOH, -OH phenolic, and -OH alcoholate. Humic acid can directly improve metabolic processes in plants, such as increasing root respiration, protein synthesis, and nucleic acid. Indirectly humic acid can improve soil properties, so that nutrient uptake by plants can increase, so plant growth will also increase (Piccolo *et al.* 1992). Vermicompost is one of the organic fertilizers derived from agricultural and livestock waste by utilizing earthworms during composting (Hasyim *et al*. 2014). Vermicompost contains various biological ingredients or components, including growth hormones such as Ggibberellins 2.75%, Ccytokinins 1.05%, and Aauxins 3.80% (Manshur 2001). In addition, vermicompost contains complete nutrients, both macro and microelements, useful for plant growth. Vermicompost also contains many microbes, and the process of making vermicompost is shorter than other composts. The efficiency of using vermicompost can be increased by making vermicompost extract. Vermicompost extraction aims to streamline the transportation of vermicompost so that the minerals in the vermicompost can be released into the vermicompost extract and so that plants more easily absorb it. Vermicompost extracts can positively affect crop yield quality and increase soil biological activity in several soil types. Vermicompost Extract can significantly increase the content of N, P, K, Ca, and Mg so that there is an interaction between vermicompost extract and growth media (Pant *et al*. 2011).

The application of organic matter will make inorganic fertilizers more efficient, such as SP36 or TSP fertilizers. The application of TSP fertilizer into the soil will increase the amount of available P, and the amount will be higher if the application of humic acid follows the application of P fertilizer. Without humic acid, the application of TSP fertilizer is less efficient because of the adsorption or fixation of P by Al and Fe ions, Al and Fe hydroxy and clay minerals (Jones *et al.* 1991).

The application of humic acid and TSP fertilization can improve the soil's physical, chemical, and biological properties. One of the biological properties of the soil is the number of soil microorganisms. Soil microorganism carbon biomass is the living part of soil organic matter consisting of bacteria, fungi, algae, and protozoa, excluding plant roots and soil fauna larger than the largest amoeba (approximately) (Jenkison and Ladd 1981 *in* Febry 2011). According to Buchari (1999), soil microorganism carbon biomass (C-mic) can indicate soil fertility. A high population of soil microorganisms is only possible if the soil has properties that can support the activity and development of soil microorganisms. Soil that contains various microorganisms indicates that the soil has a good level of fertility. The research aimed to study the effect of humic acid and TSP fertilization on the soil microbial carbon biomass on corn (*Zea mays* L.). The correlation between some soil properties (soil organic-C, soil moisture content, soil pH, soil temperature) and yields (stalk dry weight, and weight of corn kernels) on soil microbial carbon biomass (C-mic) on corn cultivated in ultisol soil.

MATERIALS AND METHODS

Study Site

This research was carried out at the Experimental Garden of the Agency for Research and Applied Technology, Natar, South Lampung, from December 2017 to April 2018. Soil C-mic analysis was carried out at the Soil Biology Laboratory, and soil chemical properties analysis was carried out at the Soil Science Laboratory, Faculty of Agriculture, University of Lampung.

Research Methods

This study was designed using a Randomized Block Design (RBD), which was arranged in a factorial manner with two treatment factors with three replications. The first factor was the application of humic acid, namely without the application of humic acid (h_0), the application of humic acid of commercial origin (h_1), and the application of humic acid from the vermicompost aqueous extract (h_2). The second factor was P fertilization which was divided into four dose levels, namely without TSP fertilizer (p_0), TSP fertilizer 100 kg ha^{-1} (p_1), 200 kg ha^{-1} (p_2), and 300 kg ha^{-1} (p_3).

Land Preparation

The experimental land was cleaned and measured as needed, and then it was fallowed until it was ready for planting. Tillage was carried out two times, namely by processing the soil into large chunks and then reprocessing it until smooth. The first and second processing was carried out on the same day. Then, the land was divided into 36 experimental plots with a plot size of 3 x 4 m, then divided into 3 for grouping according to treatment. The distance between plots was 50 cm, and the distance between replicates was 1 m.

Treatment and Planting

The humic acid applied to the soil surface was 4 kg ha^{-1} (4.8 g plot^{-1}), and the application of vermicompost aqueous extract was 40 L ha^{-1} (480 mL plot^{-1}). The application of humic acid and aqueous vermicompost extract was by using a hand sprayer, which was sprayed onto the soil surface. The application of humic material was carried out three times, namely during tillage, early vegetative, and maximum vegetative. Corn plants were planted with a spacing of 25 cm x 75 cm. The seeds used are hybrid corn seeds NK7328. Corn seeds were planted by inserting two corn seeds into each planting hole. At 7 DAP, Urea and KCl fertilizers were applied, each as much as 200 kg ha^{-1} as basic fertilizer, and TSP fertilizer was applied simultaneously according to the treatment dose.

Maintenance

Plant maintenance includes watering, hoarding, weeding weeds, and controlling pests and diseases. Watering was done every four days or when the plants needed watering. Watering was done by looking at the intensity of the rain that falls. Hoarding was done before the plant was more than one month old to prevent it from collapsing when it rains, and there is wind. Pest and disease control was carried out according to conditions in the field. Weeding was carried out by pulling or removing weeds in the experimental plot.

Measurement of Soil Microorganism Carbon Biomass (C-mic)

Soil samples were taken at 7 DAP, the maximum vegetative phase of the plant (56 DAP), and at the time before harvest (104 DAP). The determination of C-mic was carried out using the fumigation-incubation method (Jenkinson and Powlson 1976), which was refined by Franzluebbers *et al.* 1995).
C-mic was calculated using the formula (Wu *et al.* 1990):
The final equation calculates the carbon biomass of soil microorganisms:

$$C-mic = \frac{(mg\,C-CO_2 kg^{-1}\,10\,days)_{fumigasi} - (mg\,C-CO_2 kg^{-1}\,10\,days)_{non-fumigasi}}{Kc} (mg\,CO_2 - C\,kg^{-1}\,10\,days) = \frac{(a-b) \times t \times 120}{n}$$

Note :
a = mL HCl for soil sample
b = mL HCl for blank
n = incubation time (days)
t = normality of HCl (0.1 *N*)
Kc = 0.41 (Veroney and Paul 1984 *in* Franzluebbers *et al.* 1995).

The supporting variables observed were soil organic carbon (%) using the Walkey and Black method, soil pH using the Electrometric method, soil moisture content (%) using the Gravimetric method, soil temperature (ÚC) measured using a soil thermometer, carried out at the time of sampling. Soil samples for measuring C-mic, dry weight of the stalk were taken the day before the second observation, and the weight of the corn kernels was taken after the third observation.

Data Analysis

The data obtained were tested for homogeneity of variance with the Bartlett test, data additivity was tested with the Tukey test. Least Significant Difference (LSD) at the level of 5% to determine the correlation between C-organic, soil pH, soil temperature, soil moisture content, stalk dry weight, and weight of corn kernels with C-mic a correlation test was performed using the equation Y=a +b (x).

RESULTS AND DISCUSSION

Soil Biomass Carbon Microorganism (C-mic)

The results (Table 1) showed that the application of humic acid, vermicompost extract, and TSP fertilization, as well as the interaction between the two, did not significantly affect the C-mic of the soil at 7 DAP, 56 DAP, and 104 DAP observations.

The absence of the effect of the humic acid application on C-mic is suspected because the relatively short observation time has not been able to change the soil properties in the research area, so the microorganism living environment has not been appropriately met. The relatively short time of giving humic acid is not enough to improve soil structure, and good soil structure can affect microorganisms' environment, such as soil moisture content, pH, soil moisture, and soil temperature.

The treatment of TSP fertilization on the research land did not significantly affect the soil microorganism carbon biomass (C-mic). The lack of effect of TSP fertilization is suspected because TSP does not directly affect C-mic (microorganisms do not eat P fertilizer), corn plants absorb TSP fertilizer to increase the growth of corn plants, and fertile corn plants will increase C-mic. The land has not been planted with corn; the level of P-availability is low, namely 5.17 mg kg^{-1}, so that the land needs to be given high P fertilizer. According to Buckman and Brady (1969), element P has a significant role for corn plants on respiration, transfer, and use of energy (ATP-ADP-AMP), cell division, meristem tissue growth, and the formation of generative parts such as flowers and fruit.

The C-mic value at 7 DAP showed low yields and increased at the maximum vegetative phase of corn (56 DAP) and decreased at 104 DAP. When the corn plants were 7 DAP, the C-mic value ranged from 11.72 mg C-CO_2 kg soil^{-1} ten days^{-1} to 18.81 mg C-CO_2 kg soil^{-1} 10 days^{-1}. Meanwhile, the C-mic value at 56 DAP ranged from 14.81 mg C-CO_2

Table 1. Analysis of variance on the effect of application of humic acid and TSP fertilization on soil C-mic at 7 DAP, 56 DAP, and 104 DAP observations on corn (*Zea mays* L.).

Treatment	7 DAP	56 DAP	104 DAP
		........................mg $C\text{-}CO_2$ kg soil^{-1} 10 days^{-1}........................	
h_0p_0	14.67	4.19	12.78
h_0p_1	11.76	4.14	12.39
h_0p_2	14.60	4.34	12.98
h_0p_3	14.37	4.06	14.63
h_1p_0	11.72	5.04	16.78
h_1p_1	13.05	3.83	12.00
h_1p_2	15.82	4.00	13.17
h_1p_3	12.05	4.32	14.34
h_2p_0	16.87	4.23	12.98
h_2p_1	17.51	5.26	15.80
h_2p_2	16.33	4.71	15.12
h_2p_3	18.81	5.51	13.85
Source Diversity		F value and Significance	
h	1.85^{ns}	2.16^{ns}	0.30^{ns}
p	0.12^{ns}	0.14^{ns}	0.09^{ns}
h x p	0.24^{ns}	0.97^{ns}	0.58^{ns}

kg soil^{-1} ten days^{-1} to 31.67 mg $C\text{-}CO_2$ kg soil^{-1}10 days^{-1}. Uncertain C-mic value was presumably due to the effect of plants in the maximum vegetative phase affecting the increase in soil CO_2 originating from increased root exudates, thus causing the activity of microorganisms in the soil to increase. Microorganisms in the soil are usually abundant in the area around the roots because the roots secrete various secretions in amino acids, carbohydrates, vitamins, and enzymes, which are a source of nutrition for soil microorganisms (Kelting *et al.* 1998).

The C-mic value when corn plants were 104 DAP decreased from 56 DAP observations. The C-mic value at 56 DAP ranged from 14.81 mg $C\text{-}CO_2$ kg soil^{-1} ten days^{-1} to 31.67 mg $C\text{-}CO_2$ kg soil^{-1} 10 days^{-1} and when corn plants were aged 104 DAP, ranging from 12.00 mg $C\text{-}CO_2$ kg soil^{-1} 10 days^{-1} to 16.78 mg $C\text{-}CO_2$ kg soil^{-1} 10 days^{-1}. The lower C-mic value when the plant at 104 DAP was due to the plant roots not actively developing, reducing soil microorganisms in the area around the roots. If the activity of soil microorganisms decreases, it will cause the amount of CO_2 to decrease and causes the C-mic value to decrease.

Soil Physical and Chemical Properties on Corn Cultivation Land (*Zea mays* L.)

The results of the C-organic analysis of the soil (Table 2), at 7 DAP observations ranged from 1.09% - 1.32%, 56 DAP observations ranged from 1.11% - 1.38%, and 104 DAP observations ranged from 1.12 % - 1.39%. Soil organic carbon is classified as low if the C-organic value is below 2%. The variance analysis showed the interaction between the application of humic acid (Table 3); presumably, at 56 DAP, the plants were in the maximum vegetative phase, so the plants were actively developing, causing soil organic carbon to have a significant effect. Soil organic carbon was vital because it is a source of energy for soil microorganisms to carry out their life activities.

The results of the analysis of soil water content (Table 4), at 7 DAP observations ranged from 32.52% - 33.81%, 56 DAP observations ranged from 32.69% - 35.86%, and 104 DAP observations ranged from 34.06 % - 37.77%. At 104 DAT observations, the soil water content was higher than other observations because it was raining at the observation time.

The results of soil pH measurements (Table 5), at 7 DAP observations, the soil pH ranged from 4.49 to 4.77, 56 DAP observations ranged from 4.44 to 4.79, and observations at 104 DAP ranged from 4.53 to 4.98. Soil pH in the research area was classified as acidic. According to Handayanto and Khairiah (2009), soil pH is important because soil organisms and plants are very responsive to chemical properties in their environment. Most plants and soil organisms like a neutral pH ranging from 6-7 because the availability of nutrients is relatively high at that pH.

Table 2. Analysis of variance on the effect of application of humic acid and TSP fertilization on soil organic C (%) at 7 DAP, 56 DAP, and 104 DAP observations on corn (*Zea mays* L).

Treatment	Soil Organic Carbon (%)			Soil Temperature (C)			Stalk dry weight (Mg ha^{-1})
	7 DAP	56 DAP	104 DAP	7 DAP	56 DAP	104 DAP	55 DAP
h_0p_0	1.17	1.14	1.21	27.33	28.87	29.37	3.61
h_0p_1	1.09	1.11	1.20	27.17	28.77	29.00	4.05
h_0p_2	1.17	1.25	1.15	27.00	28.67	28.73	5.57
h_0p_3	1.20	1.18	1.12	27.33	28.40	28.93	5.80
h_1p_0	1.28	1.38	1.34	27.17	28.93	28.80	4.19
h_1p_1	1.10	1.18	1.19	27.33	28.80	29.07	5.26
h_1p_2	1.25	1.22	1.28	27.33	28.90	29.17	5.11
h_1p_3	1.21	1.19	1.22	27.00	28.73	28.77	6.22
h_2p_0	1.21	1.22	1.21	27.50	29.43	28.67	3.86
h_2p_1	1.32	1.37	1.39	26.83	28.47	28.50	6.11
h_2p_2	1.17	1.16	1.17	27.33	28.70	28.83	6.94
h_2p_3	1.20	1.20	1.18	27.50	28.60	28.97	6.17
Source Diversity	F value and Significance						
h	1.36^{ns}	2.02^{ns}	1.72^{ns}	0.18^{ns}	1.32^{ns}	0.67^{ns}	9.00^{*}
p	0.35^{ns}	0.63^{ns}	1.09^{ns}	0.51^{ns}	6.14^{*}	0.04^{ns}	25.44^{*}
h x p	1.52^{ns}	3.27^{*}	1.27^{ns}	1.17^{ns}	2.09^{ns}	0.62^{ns}	3.14^{*}

Note: h_0= No application of humic acid. h_1= Application of commercial humic acid, and h_2= Application of humic acid from vermicompost extracts.

The results of soil temperature measurements (Table 2), at 7 DAP observations the soil temperature ranged from 26.83 °C – 27.50 °C, 56 DAP observations ranged from 28.40 °C – 29.43 °C and 104 DAP observations ranged between 28.50 °C – 29.37 °C. The analysis of variance showed that the application of P fertilization had a significant effect on soil temperature at 56 DAP observations. Treatment without applying P fertilization resulted in higher soil temperatures than TSP fertilization 100 kg ha^{-1}, TSP fertilization 200 kg ha^{-1}, and 300 kg ha^{-1} (Table 4). At p_0, the dry stalk weight was lower than p_1, p_2, and p_3. If the plant is low, the crown is less dense, and sunlight enters directly into the soil, causing higher temperatures.

The results of the calculation of the dry weight of the stalk (Table 2) showed that the interaction between humic acid and TSP fertilization had a significant effect on the dry weight of the stalk (Table 6), the lowest dry weight of the stalk in the h_0p_0 treatment was 3.61 (Mg ha^{-1}), and the highest was in the h_2p_2 treatment was 6.94 (Mg ha^{-1}). The results followed Parlindungan (2011) statement, which states that applying humic acid and P fertilizer can increase corn plants' P content and dry weight at a concentration of 800 mg L^{-1}.

Table 3. Effect of interaction between humic acid and TSP fertilization on C-organic of soil (%) on corn (*Zea mays* L.). [Keterangan tabel 3 belum ada pada naskah].

Treatment	TSP fertilization			
	p_0	p_1	p_2	p_3
Soil Organic Carbon (%)				
h_0	1.14 a	1.11 a	1.25 a	1.18 a
	(B)	(B)	(A)	(A)
h_1	1.38 a	1.18 b	1.22 ab	1.19 b
	(A)	(B)	(A)	(A)
h_2	1.22 ab	1.37 a	1.16 b	1.2 b
	(AB)	(A)	(A)	(A)
LSD (0.05)	0.16			

Table 4. Effect of humic acid application and TSP fertilization on soil temperature (°C) on corn (*Zea mays* L.) 56 DAP.

Treatment	Soil Temperature (°C)
No TSP fertilizer (p_0)	29.08 a
TSP Fertilizer 100 kg ha^{-1} (p_1)	28.68 b
TSP Fertilizer 200 kg ha^{-1} (p_2)	28.76 b
TSP Fertilizer 300 kg ha^{-1} (p_3)	28.58 b
LSD (0.05)	0.26

Note: The mean value followed by the same letter is not significantly different based on the LSD test at the 5% level.

Based on the correlation test results (Table 7), it was shown that the application of humic acid and P fertilization, soil organic carbonate 7 DAP, 56 DAP, and 104 DAP gave a significant correlation to soil microorganism carbon. The effect of C-organic on soil properties is that it can improve the physical condition of the soil for the better and help provide water and nutrients for plants. According to Nursyamsi *et al*. (1996), the more organic acids added to the soil will increase the population of soil microorganisms, this affects the increase in microorganism activity to increase the carbon biomass of microorganisms (C-mic) in the soil.

Soil moisture content significantly correlated to soil C-mic at 7 DAP observations, while at 56 DAP observations and 104 DAP observations did not provide a significant correlation with soil C-mic.

The correlation test results (Table 7) showed that soil pH at 7 DAP did not significantly correlate to soil C-mic, while 56 DAP and 104 DAP observations showed a significant correlation to soil C-mic. According to Hakim *et al.* (1986), the process of decomposition of organic acids by soil microorganisms can result in low soil pH because this process causes the presence of organic acids and leaching due to erosion so that only Al and H^+ cations are the dominant cations that cause the soil too acid reaction.

Soil temperature at 7 DAP and 56 DAP did not give a significant correlation to soil C-mic, while at

Table 5. Analysis of variance on the effect of humic acid and TSP fertilization application on soil moisture content (%) at observations of 7 DAP. 56 DAP. and 104 DAP on corn (*Zea mays* L.).

Treatment	Soil Moisture Content (%)			Soil pH			Corn Kernels Weight (Mg Ha^{-1})
	7 DAP	56 DAP	104 DAP	7 DAP	56 DAP	104 DAP	113 DAP
h_0p_0	33.51	35.86	37.77	4.49	4.50	4.59	11.13
h_0p_1	33.63	33.87	35.20	4.60	4.58	4.73	10.31
h_0p_2	33.29	33.51	34.06	4.54	4.49	4.53	11.38
h_0p_3	33.57	33.04	36.51	4.66	4.47	4.58	13.21
h_1p_0	32.52	33.46	35.60	4.58	4.44	4.91	12.43
h_1p_1	33.45	33.45	34.53	4.57	4.47	4.80	12.00
h_1p_2	32.86	32.69	36.35	4.53	4.53	4.79	12.69
h_1p_3	33.39	35.11	35.94	4.51	4.47	4.54	12.81
h_2p_0	33.46	34.74	35.48	4.52	4.46	4.63	10.93
h_2p_1	33.63	34.41	35.57	4.77	4.79	4.98	12.74
h_2p_2	33.81	33.28	35.53	4.51	4.45	4.68	13.50
h_2p_3	33.57	35.37	35.52	4.59	4.54	4.69	11.99
Source Diversity	F value and Significance						
h	1.80^{ns}	0.52^{ns}	0.31^{ns}	0.38^{ns}	0.53^{ns}	2.56^{ns}	3.00^{ns}
p	0.54^{ns}	1.24^{ns}	2.03^{ns}	1.51^{ns}	0.94^{ns}	2.61^{ns}	2.93^{ns}
h x p	0.36^{ns}	0.84^{ns}	2.46^{ns}	0.89^{ns}	0.56^{ns}	1.23^{ns}	2.50^{ns}

Table 6. The interaction effect of humic acid and TSP fertilization on the dry weight of stalk (Mg ha^{-1}) at 55 DAP observations on corn (*Zea mays* L.).

Treatment	TSP Fertilization			
	p_0	p_1	p_2	p_3
	the dry weight of stalk (Mg ha^{-1})			
h_0	3.61 b	4.05 b	5.57 a	5.8 a
	(A)	(B)	(B)	(A)
h_1	4.19 b	5.26 ab	5.11 b	6.22 a
	(A)	(A)	(B)	(A)
h_2	3.86 b	6.11 a	6.94 a	6.17 a
	(A)	(A)	(A)	(A)
LSD (0.05)	0.99			

104 DAP observations gave a significant correlation to soil C-mic. Soil temperature was negatively correlated with soil microorganism carbon biomass (C-mic) at 104 DAP observations (Table 7), which means that the higher the soil temperature, the lower the C-mic. According to Pauza (2016), soil pH and soil temperature significantly affect soil C-mic.

The dry weight of the stalk and the corn kernels were significantly correlated with the soil C-mic. The high dry weight of the stalk and the high weight of the corn kernels indicated that the plant was fertile. Fertile plants have many roots (roots spread), and the plant's crown is getting closer. The density of soil cover due to plant crowns causes the fulfillment of the living environment of soil microorganisms. Corn plant roots release a lot of root exudate, which can be used as an energy source for soil microorganisms. The results of this study are in line with the results of research by Pant *et al.* (2011) on the application of vermicompost extracts that can improve soil biological properties, improve plant growth, and yield the quality of pakcoy plants.

CONCLUSION

The application of humic acid with P fertilizer and the interaction of humic acid and P fertilizer did not affect the carbon biomass of microorganisms at 7 DAP, 56 DAP, and 104 DAP observations. However, the application of humic acid in P fertilization on corn plant growth was significantly higher. The higher the C-organic content of the soil, the higher the C-mic, the higher the percentage of soil water content at 7 DAP, the C-mic increased. The higher the soil pH at 56 DAP and 104 DAP, the soil C-mic was increased and positively correlated. Likewise, for the stalk, dry weight and kernels dry weight of the C-mic. However, it is negatively correlated to soil temperature.

ACKNOWLEDGMENT

The authors thank Ir. Abdul Hamid has provided commercial humic acid as a research treatment and to the Experimental Station of the Assessment

Table 7. Correlation test between C-organic soil, soil moisture content, soil pH, soil temperature, dry weight of stalk, and weight of corn kernels on C-mic.

Observation	Correlation coefficient (r)		
	Soil Microorganism Carbon		
	7 DAP	56 DAP	104 DAP
C-organic (%)	0.34^{*}	0.59^{*}	0.53^{*}
Soil Moisture Content(%)	0.36^{*}	0.29^{ns}	0.12^{ns}
Soil pH	0.20^{ns}	0.42^{*}	0.43^{*}
Soil Temperature (°C)	0.10^{ns}	-0.28^{ns}	-0.52^{*}
Dry Weight of Stalk(t ha^{-1})	-	0.34^{*}	-
Weight of Corn Kernels(t ha^{-1})	-	-	0.65^{*}

Note: DAP = Days after planting;ns= no significant effect 5% level;* = significant effect at 5% level.

Institute for Agricultural Technology, Natar, who has given land use permits for this research.

REFERENCE

Buchari H. 1999. Penetapan Karbon Mikrobial (C-mik) pada DuaTipe Penggunaan Lahan (Alang-alang dan Hutan) dengan Metode Fumigasi-Ekstraksi sebagai Indikator Degradasi Tanah. Program PascaSarjana (Paper). Institut Pertanian Bogor. (in Indonesian).

Buckman HO and NC Brady. 1969. The Nature and Properties of Soil. The Macmillan Company. New York. Diterjemahkan oleh Soegiman. 1982. Ilmu Tanah. Bhratara Karya Aksara. Jakarta.

Febry RP. 2011. Pengaruh sistem olah tanah pada lahan alang-alang terhadap kandungan biomassa mikroorganisme tanah (C-mik) yang ditanami jagung (*Zea mays* L.). Skripsi. Fakultas Pertanian Universitas Lampung. Bandar Lampung. Hlm 21-30. (in Indonesian).

Franzluebbers AJ, DA Zuberer and FM Hons. 1995. Comparison of Microbiological Methods for Evaluating Quality and Fertility of Soil. *Biol and Fertil Soils* 19: 135-140.

Hakim N, Nyakpa YM, Lubis MA, Nugroho GS, Saul RM, Diha AM, Hong BG, Bailey HH. 1986. Dasar-Dasar Ilmu Tanah.Universitas Lampung. Lampung. 488 hlm. (in Indonesian).

Handayanto E and K Hairiah. 2009. Biologi Tanah Landasan Pengelolaan Tanah Sehat. Pustaka Adipura. Yogyakarta.193 hlm. (in Indonesian).

Hasyim Z, E Tambaru and AI Latunra. 2014. Uji penambahan berbagai dosis vermikompos terhadap pertumbuhan vegetatif cabai merah besar (*Capsicum annum* L.). *J Alam dan Lingkungan* 5: 18-24. (in Indonesian)

Jones JB, B Wolf and HA Mills. 1991. Plant Analysis Handbook. A Practical Sampling, Preparation, Analysis, and Interpretation Guide. Micro-Macro Pub, Inc.

Kelting DL, JA Burger and GS Edward. 1998. Estimating root respiration, microbial respiration in the rhizosphere, and root-free soil respiration in forest soils. *Soil Biol Biochem* 30: 961-968.

Manshur. 2001. Vermikompos (Kompos Cacing Tanah) dan Pupuk Organik yang Ramah Lingkungan. Instalansi Penelitian dan Pengkajian Teknologi Pertanian (IPPTP) Mataram. Mataram. (in Indonesian)

Nursyamsi D, JS Adiningsih JS, Sholeh and A Adi. 1996. Penggunaan Bahan Organik untuk Meningkatkan Efisiensi Pupuk N dan Produktivitas Tanah Ultisol di Sitiung, Sumbar. *J Tanah Tropika* 2: 26-33.

Pant A, Radovich TJK, Hue NV, Arancon NQ. 2011. Vermicompost Tea (Aqueous Extract) on Pak Choi Yield, Quality, and on Soil Biological Properties. *Compost Sci Utilization* 19: 279-292.

Parlindungan SP. 2011. Pengaruh Bahan Humat dari Ekstrak Batu Bara Muda (Subbituminus) dari Pupuk P terhadap Ketersediaan dan Serapan Hara P Tanaman Jagung (*Zea mays* L.) pada Ultisol. Skripsi. Universitas Andalas. 65 hlm. (in Indonesian).

Pauza NM. 2016. Pengaruh Sistem Olah Tanah Dan Aplikasi Mulsa Bagas Terhadap Biomassa Karbon Mikroorganisme Tanah (C-Mik) Pada Lahan Pertanaman Tebu (*Saccharum officinarum*L.) Tahun Ke-5. Skripsi. Fakultas Pertanian, Universitas Lampung. 46 hlm. (in Indonesian)

Piccolo A, Nardi S, Concheri G. 1992. Structural characteristics of humic substances as related to nitrate uptake and growth regulation in plant systems. *Soil Biol Biochem* 24:373-380.

Riniarti D, A Kusumastuty and B Utoyo. 2012. Pengaruh bahan organik, pupuk P, dan bakteri pelarut P tterhadap keragaan tanaman kelapa sawit pada Ultisol. *J Penelitian Pertanian Terapan* 12: 187-195. (in Indonesian).

Subagyo H, S Nata and AB Siswanto. 2000. Tanah-Tanah Pertanian di Indonesia dalam Sumberdaya Lahan Indonesia dan Pengelolaannya. Pusat Penelitian Tanah dan Agroklimat, Badan Penelitian dan Pengembangan Pertanian, Departemen Pertanian. Bogor. (in Indonesian)

Wahyudi. 2007. Peran asam humat dan fulvat dari kompos dalam detoksifikasi aluminium pada tanah masam. *Buana Sains* 7: 123-130.

Wu J, RG Joergensen, B Pommerening, R Chaussod and PC Brookes. 1990.Measurement of soil microbial biomass C by fumigation extraction: an automated procedure. *Soil Biol Biochem* 22, 1167–1169. https://doi:10.1016/0038- 0717(90)90046-3.