Available online at:
http://journal.unila.ac.id/index.php/tropicalsoil
DOI: 10.5400/jts.2017.v22i1.37-45

Activity of Soil Microorganisms During the Second Growing Season of Sweet Corn (*Zea Mays* Saccharata Sturt) Applied with Organonitrophos and Biochar

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Received 30 October 2016/ accepted 02 January 2017

ABSTRACT

Efforts to increase the production of sweet corn can be done, among others, by the application of fertilizers, either inorganic, organic or its combination. In addition, the application of soil amendments such as biochar is expected to improve soil fertility that will further increase the production of sweet corn. Organonitrophos fertilizer is an organic fertilizer developed by lecturers of Faculty of Agriculture, University of Lampung. The research was aimed to study the effect of the combination of organonitrophos and inorganic fertilizers, biochar and the interaction between fertilizer combination and biochar on soil respiration and soil microbial biomass.The research was conducted at the Agriculture Experimental Field of University of Lampung using a Randomized Block Design with 6×2 factorials and 3 replications. The first factor was six levels of combination of organonitrophos and inorganic fertilizers (P_0, P_1, P_2, P_3, P_4, and P_5). The second factor was two levels of biochar dosage (B_0 and B_1). The data were analyzed using Analysis of Variance and further tested using the Least Significant Difference (LSD) Test at 5% significance level. The variables measured were soil respiration and soil microbial biomass carbon (SMBC). The results showed that the highest soil respiration was observed in the plots with P_3B_1 treatment (300 kg Urea ha^{-1}, 125 kg SP-36 ha^{-1}, 100 kg KCl ha^{-1} + 2500 kg organonitrophos ha^{-1}) at 60 days after planting (DAP). Among other treatments, the highest SMBC was observed in the plots with P_5 treatment (5,000 kg Organonitrophos ha^{-1}) at 60 and 90 DAP. Soil respiration and SMBC were higher in the plots with B_1 treatment (5,000 kg biochar ha^{-1}) compared to that in the plots with B_0 treatment (0 kg biochar ha^{-1}). There was an interaction effect between combination of organonitrophos and inorganic fertilizers, and biochar on soil respiration at 90 DAP. However, there was no interaction effect between fertilizer combination and biochar on SMBC.

Keywords: Biochar, fertilizer combination, organonitrophos, soil microbial biomass carbon, soil respiration

ABSTRAK

Upaya untuk meningkatkan produksi jagung manis dapat dilakukan dengan pemberian pupuk, baik berupa pupuk anorganik, organik atau kombinasi keduanya. Selain itu, pemberian bahan pembenah tanah seperti *biochar* juga diharapkan dapat memperbaiki kesuburan tanah dan secara tidak langsung juga dapat meningkatkan produksi jagung manis. Penelitian ini bertujuan untuk mempelajari pengaruh perlakuan kombinasi pupuk organonitrofos dan pupuk kimia, biochar serta interaksi antara kombinasi perlakuan pupuk dan biochar terhadap respirasi dan C-mik tanah. Penelitian dilaksanakan di Laboratorium Lapang Terpadu Universitas Lampung menggunakan faktorial 6×2 dalam Rancangan Acak Kelompok dengan 3 ulangan. Data dianalisis dengan sidik ragam dan dilanjutkan dengan Uji Beda NyataTerkecil (BNT) pada taraf 5%. Variabel yang diamati adalah aktivitas mikroorganisme tanah yaitu respirasi tanah dan biomassa karbon mikroorganisme tanah (C-mik). Hasil penelitian menunjukkan bahwa perlakuan P_3B_1 (300 kg Urea ha^{-1}, 125 kg SP-36 ha^{-1}, 100 kg KCl ha^{-1} + pupuk organonitrofos 2500 kg ha^{-1}) menghasilkan respirasi tertinggi pada saat tanaman jagung berumur 60 HST (hari setelah tanam). Perlakuan P_5 (Pupuk organonitrofos 5.000 kg ha^{-1}) memiliki nilai C-mik tertinggi dibandingkan dengan perlakuan lainnya pada saat tanaman jagung berumur 60 dan 90 HST. Perlakuan

P_5 (Pupuk organonitrofos 5.000 kg ha^{-1}) memiliki nilai C-mik tertinggi dibandingkan dengan perlakuan lainnya pada saat tanaman jagung berumur 60 dan 90 HST. Perlakuan B_1 (*biochar* 5.000 kg ha^{-1}) memiliki respirasi tanah dan C-mik lebih tinggi dibandingkan dengan perlakuan tanpa *biochar* (B_0). Terdapat interaksi antara pemberian pupuk organonitrofos dan kimia dengan penambahan *biochar* terhadap respirasi tanah pada saat tanaman jagung berumur 90 HST. Namun, tidak terdapat interaksi antara pemberian pupuk organonitrofos dan kimia dengan penambahan *biochar* terhadap C-mik tanah.

Kata kunci : *Biochar*, C-mik tanah, kombinasi pupuk, organonitrofos, respirasi tanah

INTRODUCTION

In Indonesia, corn is the second most important food crop after rice. One of the causes of low corn production in Lampung Province is due to the type of soil, which is dominated by Ultisols that has undergone further weathering. The characteristics of this soil are poor in nutrient content and mineral deposits such as P, Ca, Mg, Na, and K, high levels of Al, low cation exchange capacity, and sensitive to erosion (Prasetyo and Suriadikarta 2006). Based on these soil conditions, improvement on soil fertility is needed. One of the efforts to improve the fertility of the soil is by fertilization using organic fertilizers, inorganic fertilizers or a combination of both fertilizers.

One type of organic fertilizer that can be used is organonitrophos (Nugroho *et al.* 2012). Organonitrophos fertilizer is made from 70-80% cow dung and 20-30% phosphate rocks, with the addition of N-fixing microbes and P-solubilizing microbes. Then, the formulation of organonitrophos fertilizer is changed into a mixture of cow dung, chicken manure, dolomite, ash, and industrial solid waste of MSG (Monosodium Glutamate) with the addition of N-fixing microbes and P-solubilizing microbes. Besides fertilizer, biochar can be used as well to improve the fertility of Ultisols. Biochar is a carbonaceous material derived from biomass such as wood, which is heated in a container with little or no air (Lehman and Joseph 2009). The study of Sukartono *et al.* (2014) indicated that there is an improvement of soil physical properties after application of biomass (manure, biochar and straw). Application of biochar to soil increases carbon content, water retention and nutrients in the soil. The study of Gani (2009) indicated that biochar applications much more effectively improve the retention of nutrients to plants than any other organic materials, such as compost or manure. The soil organic matter content plays important roles on the improvement of physical, chemical or biological properties of the soil, which will affect the level of soil fertility. One of the important soil biological properties is the presence of microorganisms in the soil.

Soil microorganisms decompose plant litter and residues into soil organic matter, which further can improve soil quality through increasing soil aggregation and aeration and decreasing soil bulk density (Dominy and Haynes 2002, Franzluebbers *et al.* 1999, Spaccini *et al.* 2002, Haynes and Naidu 1998). The activity of soil microorganisms can be measured through the rate of soil respiration and soil microbial biomass carbon (SMBC). An extraction method for measuring SMBC has been proposed by Vance *et al.* (1987). Soil respiration is defined as the sum of all metabolic activities that produce CO_2 or absorb O_2 from the soil. The soil with high organic materials contains the high number of microorganisms because the soil provides the substrate that can support the life of the microorganisms (Azizah *et al.* 2007). Biomass of soil microorganisms represents a portion of the total fraction of carbon and nitrogen in soil. However, the biomass of soil microorganisms is relatively easy to change so that the activity and the quality of the microbial biomass is a factor that controlls the amount of soil C and N. The number of microbial biomass in soil depends on the quantity, quality, and distribution of C-input, which vary with time and soil depth (Kaiser and Heinemeyer 1993). Application of rice husk biochar combined with organonitrophos and inorganic fertilizers are expected to improve the nature of physical, chemical, and biological soil properties, increase the absorption of nutrients by plants, as well as probably increase the production of corn. This research was conducted in the second growing season of sweet corn, which aimed to study the influence of the combination of organonitrophos and inorganic fertilizer, biochar and the interaction between a combination of fertilizer and biochar on soil respiration and SMBC during the growth of sweet corn.

MATERIALS AND METHODS

The research was carried out at the Agriculture Experimental Field of University of Lampung using a randomized block design with 6×2 factorials and 3 replications. The first factor was 6 levels of

Table 1. The dosages of combination of organonitrophos and inorganic fertilizer in each treatment.

Treatment	Combination of fertilizer (%)		Fertilizer Dose (kg ha^{-1})			
	OP	Inorganic	OP	Urea	SP-36	KCl
P_0	0	0	0	0	0	0
P_1	0	100	0	600	250	200
P_2	25	75	1,250	450	187.5	150
P_3	50	50	2,500	300	125	100
P_4	75	25	3,750	150	62.5	50
P_5	100	0	5,000			

OP = Organonitrophos

Table 2. Dose of biochar applied in the experiment.

Treatment	Biochar (%)	Biochar Dose (kg ha^{-1})
B0	0	0
B1	100	5,000

fertilizer combinations of organonitrophos and inorganic fertilizer (Table 1). The second factor was 2 levels of *biochar* dosage (Table 2). Data were analysed using ANOVA and further tested using LSD test at 5% siginificance level. The variables measured were soil microorganism activities namely soil respiration and soil microbial biomass carbon (SMBC).

Organonitrophos fertilizer contains very high N and available-P, total-K, and has a neutral pH as can be seen in Table 3.

The size of each experimental plot was 3m × 2 m and the distance between plot was 50 cm. Two corn seeds were planted in each planting hole with a distance of 70 cm × 25 cm. Six days after planting, the plants were thinned, so a healthy growing plant was remained (in accordance with the respective treatment). Inorganic fertilizer (KCl and SP-36) and ½ dosage of urea were applied 2 weeks after planting. The rest of urea (the remaining ½ dosage) was applied at the end of the vegetative growth. Inorganic fertilizers were placed at 5 cm of soil depth.

Soil samples for soil respiration and SMBC measurements were taken at 0, 15, 30, 60 and 90 DAP (days after planting). Soil samples were taken using a soil auger at 0-10 cm depth. Five sampling points were taken in each plot then the soil samples were compiled and further stored in a refrigerator. Soil respiration was analysed using Verstraete method (Franzluebbers *et al*. 1995) and SMBC was analysed using Fumigation-Incubation Method (Jenkinson and Powlson 1976). In addition, soil characteristics including water content (Volumetric method), pH (Electrometric method), Organic-C (Walkley and Black method), Total-N (Kjeldahl method), available-P (method of Bray), soil temperature and available-K (NH_4OAc method) were analysed on soil samples taken before planting and after harvesting of corn.

Table 3. Initial characteristics of Ultisols Gedong Meneng, organonitrophos and biochar.

Analysis Type	*Biochar*	Soil	Organonitrophos	Criteria (*)
Total-N (%)	0.76	0.28	1.13	very high
Total-P (%)	-	-	5.58	very high
Total-K (%)	-	-	0.68	high
Available-P (ppm)	26.83	6.9		
		0.45		
Exchangeable-K (%)	1588.0	3		
Organic-C (%)	14.65	1.76	9.52	very high
CEC (me 100 g^{-1})		6.4		
pH	7.9	6.47	5.69	Neutral

*Criteria proposed by Balittanah (2005)

RESULTS AND DISCUSSION

The Effects of Combination of Organonitrophos and Inorganic Fertilizer with the Addition of Biochar on Soil Chemical Properties

Changes of soil properties after harvesting of corn in the second growing season are presented in Table 4. The highest soil available-P was measured in the plots with P_2B_1 treatment (75% inorganic fertilizer and 25% Organonitrophos + Biochar), with the increase of available P more the 700% of the initial amount. The increase of exchangeable-K that was close to 100% of the initial amount was observed in the plots with P_4B_1 treatment (25% chemical fertilizers and 75% Organonitrofos + Biochar).

However, soil total-N declined throughout all the treatments. This result is in line with the study of Koswara (1983) that showed that corn plants take up all N during their growth. Nitrogen is absorbed during the growth of the plant until the seed maturation, so the plant requires the available N continuously until the formation of the seed. Soil pH was not affected by the application of combined fertilizers and biochar. On the contrary, the study of Nisa (2010) showed that application of biochar 10 Mg ha^{-1} could increase the soil pH from 6.78 to 7.40 or about 9.14% increase.

The Effects of Combination of Organonitrophos and Inorganic Fertilizer with the Addition of Biochar on Soil Respiration

The effects of combination of organonitrophos and inorganic fertilizer with the addition of biochar on soil respiration are presented in Table 5. The results indicated that application of fertilizer combination significantly affected soil respiration at 0 and 90 DAP of corn plants. However, the addition of biochar did not significantly affect the soil

Table 4. Soil chemical properties taken after harvesting of corn in the second growing season.

Treatment	Total-N (%)	Available-P (ppm)	Exch-K (%)	Organik-C (%)	CEC (me $100g^{-1}$)	pH
P_0B_0	0.13	2.43	0.42	1.12	6.12	6.30
P_1B_0	0.11	1.52	0.30	0.94	8.90	5.83
P_2B_0	0.15	10.66	0.56	1.46	6.63	6.26
P_3B_0	0.16	45.44	0.88	1.55	7.15	6.41
P_4B_0	0.11	1.91	0.32	0.96	8.90	6.22
P_5B_0	0.18	25.62	0.71	1.72	10.13	6.36
P_0B_1	0.11	1.61	0.58	1.21	8.05	6.17
P_1B_1	0.16	2.51	0.55	1.31	6.90	6.05
P_2B_1	0.12	49.71	0.72	1.32	7.25	6.23
P_3B_1	0.22	30.70	0.63	1.72	6.85	6.30
P_4B_1	0.17	36.52	0.81	1.88	6.86	6.32
P_5B_1	0.12	12.50	0.59	1.55	7.94	6.55

P_0= without fertilizer; P_1 = 100% chemical fertilizer; P_2 = 75% chemical fertilizer and 25% Organonitrophos; P_3 = 50% chemical fertilizers and 50% Organonitrophos; P_4 = 25% chemical fertilizer and 75% Organonitrophos; P_5 = 100% Organonitrophos; B_0 = without biochar; B_1= biochar

Table 5. Analysis of variance (ANOVA) of soil respiration due to the application of combination of organonitrophos and inorganic fertilizers with the addition of biochar.

Sources of Diversity	Soil Respiration (kg C-CO_2 ha^{-1} day^{-1})				
	Days After Planting (DAP)				
	0	15	30	60	90
Fertilizers (P)	*	ns	ns	ns	*
Biochar (B)	*	ns	ns	ns	ns
Interaction	ns	ns	ns	ns	*

* =significantly different at P<0.05, ** = significantly different at P<0.01, ns = not significant

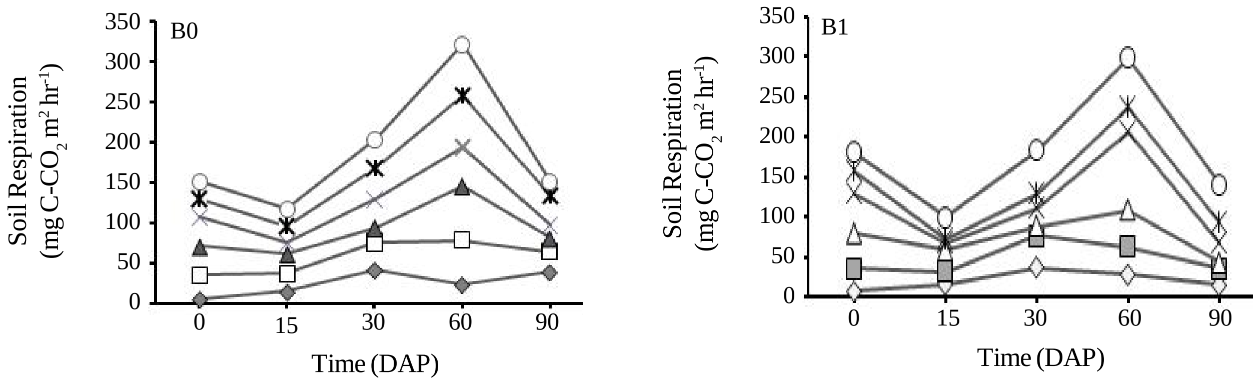

Figure1. Dynamics of soil respiration without biochar (B_0) with biochar (B_1) during the growth of corn plants. P_0 = without fertilizer; P_1 = 100% inorganic fertilizer; P_2 = 75% inorganic fertilizer and 25% Organonitrophos; P_3 = 50% inorganic fertilizers and 50% Organonitrophos; P_4 = 25% inorganic fertilizers and 75% Organonitrophos; P_5 = 100% Organonitrophos; B_0 = without biochar, : P0B0; : P1B0; : P2B0; : P3B0, : P4B0; : P5B0, B_1 = 100% biochar, : P0B1; : P1B1; : P2B1; : P3B1, : P4B1; : P5B1.

respiration during the growth of corn plants. There was an interaction effect between fertilizer combination on soil respiration at 90 DAP.

The dynamic changes of soil respiration during the growth of corn plants are presented in Figure 1. The results showed that the soil respiration decreased at the beginning of plant growth until 15 DAP. This phenomenon is probably due to the available nutrients are used for growth of plant corn. It is likely that organic fertilizer added to the soil has not fully decomposed yet, so the available nutrient in soil are used mainly by soil micro-organisms. It looks like there is a competition among soil microorganisms to take up available nutrients and finally the population of soil microorganisms decreases.

The soil respiration increased at 15 DAP until 60 DAP of corn. The soil respiration increased along with the growth of corn plants until the end of vegetative growth. At that time, the development of the roots is already maximized so that the roots can excrete the exudates. The root exudates can be used as an energy source for soil microorganisms. In addition, some of the roots are also experiencing a death, so the roots would be decomposed and utilized by the soil microorganisms. The soil respiration decreased again at 90 DAP. This is likely due to the lack of nutrients required by plants. The nutrients are not only used for plant growth but they are also used as an energy source for soil microorganisms.

The highest soil respiration at 60 DAP of corn was observed in the plots with P_3B_1 treatment (300 kg ha^{-1} Urea, 125 kg SP-36 ha^{-1}, 100 kg ha^{-1} + KCl fertilizer organonitrophos 2500 kg ha^{-1} + 5000 kg ha^{-1}) and the lowest respiration was measured in the plots

Table 6. Interaction between fertilizer combination and biochar on soil respiration at 90 DAP of corn.

Biochar	Fertilizer Combinations					
	P_0	P_1	P_2	P_3	P_4	P_5
B_0	6.24 A (a)	4.00 B (ab)	6.09 A (a)	3.96 C (c)	2.82 CD (c)	4.89 B (c)
B_1	5.02 A (a)	4.06 B (ab)	3.94 C (c)	4.59 B (ab)	5.00 A (a)	6.58 A (a)
LSD	1.92					

P_0= without fertilizer; P_1 = 100% inorganic fertilizer; P_2= 75% inorganic fertilizer and 25% Organonitrophos; P_3= 50% inorganic fertilizers and 50% Organonitrophos; P_4 = 25% inorganic fertilizers and 75% Organonitrophos; P_5 = 100% Organonitrophos; B_0= without Biochar, B_1 = 100% biochar. The same letters indicate not significantly different based on 5% siginificance level of LSD test. Small letters are read horizontally, capital letters are read vertically.

with P_0B_0 (control). Meanwhile, the soil respiration in the plots with P_3B_0 treatment (300 kg ha^{-1} Urea, 125 kg SP-36 ha^{-1}, 100 kg ha^{-1} + KCl fertilizer organonitrophos 2500 kg ha^{-1}) was higher compared to that in the plots with P_1B_0 treatment (600 kg ha^{-1} Urea, 250 kg SP-36 ha-^{1}, 200 kg ha^{-1}KCl). This phenomenon may be due to balanced fertilization accompanied by the application of soil amendement such as biochar which can provide the needs of nutrient for corn plants and the source of energy for soil microorganisms. This result is in line with the study of Antonius and Agustiyani (2011), which showed that the highest soil respiration activity obtained in the combination of inorganic fertilizer 140 kg of urea ha^{-1}, 200 kg ha^{-1} TSP, 130 kg KCl ha^{-1} and a liquid organic fertilizer 40 liters ha^{-1}.

At 90 DAP (harvesting time), there was an interaction effect between the combination of organonitrophos and inorganic fertilizer with the addition of biochar on soil respiration (Tabel 6). Among other treatments, the highest soil respiration was observed in the treatment of 450 kg Urea ha^{-1}, 187.5 kg SP-36 ha^{-1}, 150 kg KCl ha^{-1} + 1250 kg organonitrophos ha^{-1} + without biochar (P_2B_0). By adding biochar, the treatment of Organonitrophos fertilizer 5,000 kg ha^{-1} + biochar (P_5B_1) resulted in the highest soil respiration among other treatments. The results indicated that the application of organonitrophos and inorganic fertilizer with the addition of biochar can provide enough nutrients for the growth of corn plants. In addition, the results of the decomposition of the organic materials can be used as an energy source for soil microorganisms. This result is in accordance with the study of Alexander (1977), which suggested that the activity of soil microorganisms is influenced by organic materials, humidity, aeration, and energy sources. If soil microorganism activity is high, then CO_2 production is also high.

The Effects of Combination of Organonitrophos and Inorganic Fertilizer with the Addition of Biochar on Soil Microbial Biomass Carbon (SMBC)

The results of ANOVA analysis on SMBC due to the application of fertilizers and biochar can be seen in Table 7.

The soil microbial biomass carbon (SMBC) during the growth of corn plants, in general, increased with the increase of doses of

Table 7. ANOVA of SMBC due to the application of organonitrophos and inorganic fertilizers with the addition of biochar.

Sources of Diversity	SMBC (mg CO_2-C kg^{-1}) Days After Planting (DAP)				
	0	15	30	60	90
Fertilizers (P)	*	*	ns	*	*
Biochar (B)	*	*	*	*	*
Interaction	ns	ns	ns	ns	ns

* =significantly different at P<0.05, ** = significantly different at P<0.01, ns = not significant

Table 8. Effect of the application of combination of organonitrophos and inorganic fertilizers on soil SMBC (mg CO_2-C kg^{-1}) during the growth of corn plants.

Fertilizer combination	SMBC (mg CO_2-C kg-^{1}) Days After Planting (DAP)			
	0 DAP	15 DAP	60 DAP	90 DAP
P_0 without fertilizer	33.42 a	36.44 a	72.00 a	41.08 b
P_1 (OP 0% + 100% inorganic fertilizer)	43.61 b	50.78 bc	83.95 b	39.03 a
P_2 (Op 25% + 75% inorganic fertilizer)	4.,61 b	42.54 b	86.39 b	37.66 a
P_3 (OP 50% + 50% inorganic fertilizers)	46.88 b	44.34 b	91.03 c	42.88 b
P_4 (OP 75% + 25% inorganic fertilizers)	58.20 c	30.71 a	90.78 c	50.64 bc
P_5 (OP 100% + 0% inorganic fertilizers)	51.95 c	48.00 b	94.15 c	49.56 b
LSD	7.55	4.26	8.16	8.53

Table 9. Effect of Biochar on SMBC (mg CO_2-C kg^{-1}) during growth of corn plants.

Biochar	SMBC (mg CO_2-C kg^{-1})				
	Days After Planting (DAP)				
	0 DAP	15 DAP	30 DAP	60 DAP	90 DAP
B_0	41.53a	31.60 a	28.03 a	81.45	38.91 a
B_1	51.90b	52.67 b	37.16 b	91.32 b	48.03 b
LSD	4.36	4.26	5.58	4.71	4.93

Table 10. The coefficient correlation between the soil properties and soil respiration and SMBC.

Correlation	r
Organic-C and soil respiration	0.25^{tn}
Organic-C and SMBC	0.77*
Total-N and soil respiration	-0.04^{ns}
Total-N and SMBC	0.45^{ns}
pH and soil respiration	0.49^{ns}
pH and SMBC	0.60*
Soil temperature and soil respiration	-0.18^{ns}
Total-N in corn seed and soil respiration	0.90*
Total-P in corn seed and soil respiration	0.88*
Total-K in corn seed and soil respiration	0.87*
Available-P and SMBC	0.69*
Soil water content and SMBC	0.41^{ns}
Soil temperature and SMBC	-0.27^{ns}

* =significantly different at P<0.05, ** = significantly different at P<0.01, ns = not significant

organonitrophos fertilizer (Table 8). The SMBC in the plots applied with 5,000 kg biochar ha^{-1} (B_1) was higher than that in the plots without biochar application (B_0) (Table 9). There was no interaction effect between the fertilizer combination and biochar on SMBC. This result is in contrast with our hypothesis that a combination of organonitrophos and inorganic fertilizer with the addition of biochar should comply in providing a source of energy and a habitat for soil micro organisms so that the SMBC should increase as well. The soil organic matter content affects the population and activity of soil microorganisms. The increase of soil organic matter content will lead to an increase of C-mic in soil (Iswandi and Bangun 1995). Kimetu *et al.* (2008) concluded that the application of biochar on degraded soil provides benefits related to soil water availability and soil microbial dynamics.

The single fertilizer application or combination of organonitrophos and inorganic fertilizers resulted in higher SMBC than control (without fertilizer application). It is likely that application of 600 kg ha^{-1} Urea fertilizer increased the SMBC. Handayanto and Hairiah (2007) suggested that N by is not only needed by plants but also needed by soil microorganisms in the form of ammonium (NH_4^+). The high soil N content can increase the total soil microorganisms.

The SMBC decreased at 90 DAP. In this period, the lack of nutrients in soil probably leads to a decrease in the number of microbes. In this phase the number of died microbial cells counted is more than the living cells (Volk and Wheeler 1993).

Correlations between Soil Properties or Total N, P, K of corn grains and Soil Respiration or SMBC

The results of correlations between soil respiration or SMBC and soil properties or total N, P, K of corn grains are presented in Table 10.

There were significant correlations between total N, P, K of corn grains and soil respiration (Table 10). The study of Yupitasari (2013) showed that a combination of organonitrophos fertilizer and inorganic fertilizers with a dose of 100 kg urea ha^{-1}, 50 kg SP-36 ha^{-1}, 50 kg KCl ha^{-1}, 1,000 kg Organonitrophos ha^{-1} significantly improved plant height, number of branches, uptake of N, P, and K of plant and fruit, and the yield of tomato plants during the second growing season (rainy season).

Furthermore, there were significant correlations between SMBC and organic-C, available-P, and soil pH (Table 10). The results showed that the application of organonitrophos and inorganic fertilizers with the addition of biochar increased the availability of P in soil solution so that it was able to increase the uptake of P by the plants. The P was derived from organonitrophos fertilizer that contained a very high P nutrient namely 3.4%, and from SP-36 fertilizer.

CONCLUSIONS

(1) The soil respiration decreased at the beginning of the growth of corn plants until 15 DAP. After that, the soil respiration increased until 60 DAP and then it decreased again until 90 DAP. The dynamics of soil respiration were not different between the biochar application.

(2) The soil microbial biomass carbon (SMBC) during the growth of corn plants generally increased with the increase of doses of organonitrophos fertilizer. The SMBC in the plots applied with 5,000 kg biochar ha^{-1} (B_1) was higher than that in the plots without biochar application (B_0).

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