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Activity of Soil Microorganisms During the Growth of Sweet Corn (*Zea Mays Saccharata Sturt*) in the Second Planting Time with the Application of Organonitrofos and Biochar

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ABSTRACT

Efforts to increase the production of sweet corn can be done with the application of fertilizers, either inorganic, organic orits combination. In addition, the application of soil amendments such as biochar is also expected to improve soil fertility that will indirectly 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 effect 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 in the Integrated Field Laboratory of Lampung University using 6x2 factorial in a Randomized Block Design with 3 replications. The first factor was six levels 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). Data was analyzed by Analysis of Variance and followed by the Least Significant Difference (LSD)Test at 5% level. The observed variables were soil microorganism activity likely soil respiration and soil microbial biomass. The results showed that P_3B_1treatment (300 kg Urea ha^{-1}, 125 kg SP-36 ha^{-1}, 100 kg KCl ha^{-1} + 2500 kg organoitrophos ha^{-1}) was the highest soil respiration at of 60 days after planting (DAP). P_5 treatment (5000 kg Organonitrophos ha^{-1}) has the highest soil microbial biomasscompared to other treatments at 60 and 90 DAP. B_1 treatment (5000 kg biochar ha^{-1}) has higher soil respiration and soil microbial biomasscompared to treatment (0 kg biochar ha^{-1}. There was an interaction between combination of organonitrophos and inorganic fertilizers and biochar on soil respiration at 90 DAP. However, there was no interaction between fertilizer combination and biochar on soil microbial biomass.

Keywords: Biochar, Fertilizer Combination, Organonitrophos, Soil Microbial Biomass Carbon and 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 factorial 6x2 dalam Rancangan Acak Kelompok dengan 3 ulangan. Data dianalisis dengan sidik ragam dan dilanjutkan dengan Uji Beda Nyata Terkecil (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 5000 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 5000 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* 5000 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, dan Respirasi Tanah

INTRODUCTION

In Indonesia, corn is a commodity in the world's most important food crop after rice. One of the constraints of low corn production in Lampung is a type of soil that is Ultisol which is dominated by the sandy fraction and has undergone further weathering. This soil is also poor in nutrient and mineral deposits such as P, Ca, Mg, Na, and K, high levels of Al, low cation exchange capacity, and be sensitive to erosion (Prasetyo dan Suriadikarta, 2006). Based on the soil conditions, soil fertility improvement is needed. One of the efforts to improve the fertility of the soil by fertilizing, good organic fertilizers, inorganic fertilizers or a combination of both.

One type of organic fertilizer that can be used is an alternative fertilizer namely organonitrophos (Nugroho *et al*. 2012). First formulation of organonitrophos fertilizer is made from 70-80% cow dung and 20-30% phosphate rocks, with the addition of N fixer and P-dissolving microba. However the latest formulation of organonitrophos fertilizer is made from a mixture of cow dung and chicken manure, dolomite, ash, industrial solid waste of MSG (Monosodium Glutamate) and with the addition of N fixer and P-dissolving microba. Beside fertilizer to improve the fertility of Ultisol especially to improve the biological fertility , refining soil material can be used such as biochar. 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). Research by Sukartono *et.al.* (2014), indicated that there are improvement of soil physical properties on the soil which is applied by biomass application (manure, biochar, and straw). Application of biochar to soil potentially increases levels of soil, carbon water retention and nutrient elements in the soil. Gani (2009) stated that biochar applications much more effectively improve the retention of nutrients to plants than any other organic material, such as compost or manure. The content of organic matter in the soil is essential towards the nature of the physical, inorganic or biological soil which will affect the levels of soil fertility. One of the biological properties of the soil is the presence of microorganisms in the soil.

Soil microorganisms process plant litter and residues into soil organic matter, which improves soil quality by 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 the microorganisms in soil can be observed through the rate of soil respiration and soil microbial biomass carbon (SMBC). Anextractive method for measuring SMBC has been exphoced by Vance *et al* (1987). Soil respiration is defined as the sum af all metabolic activities that generate CO_2 or produce O_2 absorbtion from the soil. The soil with high organic materials has the number of microorganisms which is also high because the soil contains the substrate that can support the life of the microorganism (Azizah *et. al*. 2007). Biomass of soil microorganisms represent a portion of the total fraction of carbon and nitrogen in the soil but is relatively easy to change so that the activity and the quality of the microbial biomass is a factor in controlling the amount of C and N. The microbial biomass content of a soil depends on the quantity, quality, and distribution of the C-input, factors that vary with time and depth (Kaiser and Heinemeyer 1993). Application of rice husk biochar with a combination of Organonitrophos and inorganic fertilizers are expected to improving the nature of the physical, chemical, and biological of the soil, increasing the absorption of nutrient elements by plants, as well as knowing their effectiveness in increasing the production of corn. This research was done in the second season and aimed to study the influence of the combination of organonitrophos and fertilizer, biochar and the interaction between a combination of fertilizer and soil microorganisms activity on the activity of soil microorganisms namely soil respiration and SMBC.

MATERIALS AND METHODS

The research was carried out in the integrated field Laboratory of Lampung University used a factorial 6x2 in a randomized block design with 3 replications. The first factor was 6 levels of fertilizer combinations (Table 1). The second factor was 2 levels of *biochar* dosage (Table 2). Data were analysis by ANOVA and followed by LSD' test at 5% level. The observed variables were soil microorganism activities namely soil respiration and soil microbial biomass carbon (SMBC).

Table 1. Combination of organonitrophos and inorganic fertilizer.

Treatment	Combination Fertilizer		FertilizerDose			
	OP	Inorganic	OP (kg ha^{-1})	Urea (kg ha^{-1})	SP-36 (kg ha^{-1})	KCl (kg ha^{-1})
P_0	0	0	0	0	0	0
P_1	0	100	0	600	250	200
P_2	25	75	1250	450	187.5	150
P_3	50	50	2500	300	125	100
P_4	75	25	3750	150	62.5	50
P_5	100	0	5000			

Op = Organonitrophos

Table 2. Dose of *Biochar* applied in the experiment.

treatment	Biochar (%)	Biochar Dose (kg ha^{-1})
B0	0	0
B1	100	5000

Organonitrophos fertilizers contained very high N and available-P, total-K, as well as a neutral soil pH as can be seen in Table 3.

Soil plot was 3 x 2 m and the distance between plot was 50 cm. Seed corn was placed as much as 2 for each hole with a plantingdistance 70 cm x 25 cm. After 6 days 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 urea were given 2 weeks after planting the seed of corn. The rest of urea (the remaining ½ dosage) was applied at the end of the vegetative growth. Inorganic fertilization was placed at 5 cm deep in soil.

Soil sampling for soil respiration and SMBC performed at 0, 15, 30, 60 and 90 DAP (day after planting). Soil samples were taken using the soil drill at a depth of 0-10 cm. Each plot was taken 5 sampling points then the soil sampling was is compiledand stored in the refrigerator. The main variables were soil respiration analysed use Verstraete method (Franzluebbers*et. al*. 1995) and SMBC analysis by using Fumigation-Incubation Method (Jenkinson and Powlson, 1976). Supporting variables were soil analysis at the initial and harvesting time water content (Volumetric method), pH (Electrometric method), the Organic-C (Walkley and Black method), Total-N (Kjeldahl method), available-P (method of Bray), soil temperature and available-K (NH_4OAc method).

RESULTS AND DISCUSSION

Effects the 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 shown in (Table 4). The highest soil available-P was measured

Table 3. Initial soil analysis of Ultisol Gedong Meneng, organonitrophos and Biochar before treatment.

Analysis Type	*Biochar*	Soil	Organonitrophos	Criteria (*)
Total-N(%)	0.76 (ST)	0.28 (S)	1.13	very high
Total-P (%)	-	-	5.58	very high
Total-K (%)	-	-	0.68	high
Available-P (ppm)	26.83 (ST)	6.9 (R)		
Exc-K (%)	1588.0 (ST)	0.453 (S)		
Organic-C (%)	14.65 (ST)	1.76 (R)	9.52	very high
CEC (me 100 g^{-1})	-	6.4 (R)		
pH	7.9 (AA)	6.47 (AM)	5.69	Netral

Table 4. Some Soil chemical Properties After Harvesting of Corn the Second Planting.

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% Organonitrofos P_3 = 50% chemical fertilizers and 50% Organonitrofos; P_4= 25% chemical fertilizer and 75% Organonitrofos; P_5 = 100% Organonitrofos; B_0 = without biochar; B_1= biochar

in P_2B_1 treatment (75% inorganic fertilizer and 25% Organonitrophos + Biochar) with the increasing more the 700% from the initial available-P. While, an increase in the Exch-K at P_4B_1 treatment (25% chemical fertilizers and 75% Organonitrofos + Biochar) closed to 100%.

However, Total-N declined throughout all treatments. This is in line with Koswara (1983) that corn plants take all N during its growth. Nitrogen is absorbed during the growth of the plant until the seed maturation, so the plant requires the availability of N continuously on all stadia growth until the formation of the seed. Soil pH did not affected by the application of combined fertilizers and biochar. On the countrary, Nisa (2010) showed the soil that given biochar 10 tons ha^{-1} could increase the soil pH from 6.78 to 7.40 or increasing 9.14%.

The dynamic changes of soil respiration during corn growth is presented in Figure 1.Shows that the soil respiration has decreased at the beginning plant growth up to 15 DAP. It is alleged that the available nutrients are used for plant growth of corn. It was likely that fertilizer added to the soil has not fully decomposed yet, so the available nutrient in soil were used by soil microorganisms. So there where competition between soil microorganisms and finally soil microorganisms partly reduced the population.

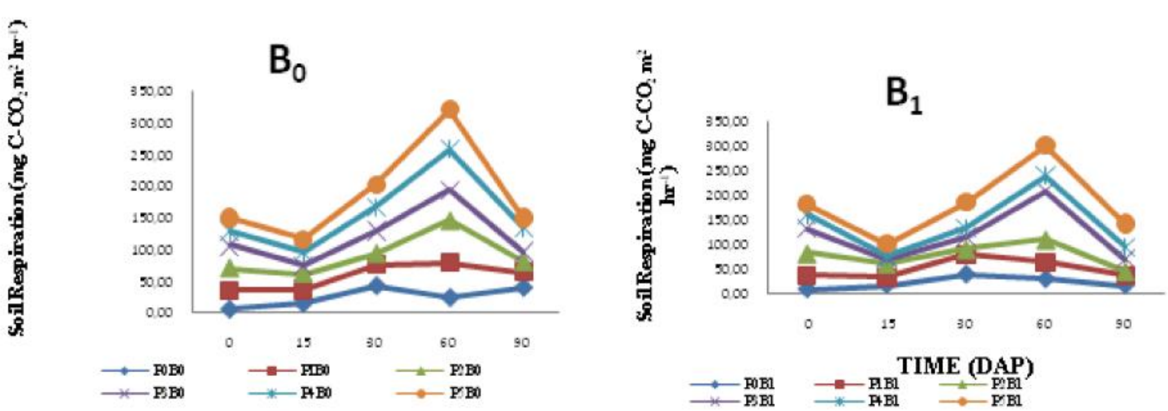

Figure1. Dynamics of soil respiration without biochar (top) with biochar (down) during the growth of corn plants. P_0 = without fertilizer; P_1= 100% inorganic fertilizer; P_2= 75% inorganic fertilizer and 25% Organonitrophos; P_3 = 50% inorganic fertilizers and 50% Organonitrophos; P_4=25% inorganic fertilizers and 75% Organonitrophos; P_5= 100% Organonitrophos; B_0= without biochar, B_1= 100% biochar.

Soil increased corn was on 60 DAP. Soil respiration then increased along with the growth of cornplants until the and of vegetative. At that time the development of the roots already maximized so that roots can issue the exudate.

This root exudate can be used as an energy source for soil microorganisms and some of the roots are also experiencing a death. So it can undergo decomposition and utilized by the soil microorganisms. Soil respiration decreased again at a time when corn plants reached 90 DAP. This was likely done to lack of nutrient elements in likely that were required by plants. Nutrient elements are not only used for plant growth but they are also used as an energy source for soil microorganisms.

The highest soil respiration at cornplants aged 60 DAP was in the 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 wasin P_0B_0 (control). Mean while, 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}) has a higher respiration compared to P_1B_0 treatment (600 kg ha^{-1} Urea, 250 kg SP-36 ha^{-1}, 200 kg ha^{-1} KCl). It is alleged by balanced fertilization accompanied with the usage of soil amendement such as biochar which can meet the needs of plant nutrient for corn and as a source of energy for the microorganisms. This is in line with the experimental results Antonius Agustiyani (2011) that the highest soil respiration activity obtained in the combination of inorganic fertilizer of 140 kg of urea ha^{-1}, 200 kg ha^{-1} TSP + 130 kg KCl ha^{-1} and a liquid organic fertilizer of 40 liters ha^{-1}.

At 90 DAP of corn (harvesting time), there was an interaction between the combination of organonitrophos and inorganic fertilizer with the addition of biochar on soil respiration (Tabel 5). It is shown that the application of organonitrophos and inorganic fertilizer with the addition of biochar can provide enough nutrient for plant growth of corn as well as the result of the decomposition of the organic material can be used as an energy source for soil microorganisms.

Table 5. Interaction between fertilizers combination and biochar on soil respiration at 90 DAP of corn.

Biochar	Fertilizers Combination					
	P_0	P_1	P_2	P_3	P_4	P_5
B_0	6.24A (a)	4.00B (ab)	6.09A (a)	3.96C (c)	2.82CD (c)	4.89B (c)
B_1	5.02A (a)	4.06B (ab)	3.94C (c)	4.59B (ab)	5.00A (a)	6.58A (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 letter is not significantly different based on 5% level of LSD test. Small letters are read horizontally, capital letters are read vertically.

Effect combination of Organonitrophos and Inorganic Fertilizer with the addition of Biochar on soil microbial Biomass carbon (SMBC)

The results of ANOVA analysis SMBC by the addition of fertilizers biochar can be seen in Table 6.

SMBC during the corn plant growth, in general, has increased with the increasing doses of organonitrophos fertilizer (Table 7). SMBC with the addition of 5000 kg biochar ha^{-1} (B_1) was higher than without biochar (B_0).There was no interaction between the fertilizers combination and biochar on SMBC.This is supposedly a combination of and inorganic fertilizers with the addition of biochar already comply in providing a source of energy and

a habitat for soil microorganisms so that the value of SMBC increase. Because the content of organic matter affect the poppulation and activity of soil microorganisms. The higher soil organic matter than C-mic ground will also increase (Iswandi and Bangun, 1995). Kimetu *et al.* (2008) concludes that the application of biochar to the degraded soil showed a benefit of biochar related to soil water availability and soil microbial dynamics.

Single fertilizers application or combination of fertilizers organonitrophos and inorganic fertilizers had higher SMBC then control. It was likely that Urea fertilizer application of 600 kg ha^{-1} increased the SMBC. According to Handayanto and Hairiah (2007), is not only needed plants but only needed by N, microorganisms in soil N content the form of

Table 6. ANOVA of SMBC due to the 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
Pupuk (P)	*	*	ns	*	*
Biochar (B)	*	*	*	*	*
Interaction	ns	ns	ns	ns	ns

* = significance at P<0,05, ** = significance at P<0,01, ns = non significance.

Table 7. Effect the combination of organonitrophos and inorganic fertilizers on soil SMBC (mg CO_2-C kg^{-1}) during the growth of corn.

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

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

ammonium ions (NH_4^+). The higher soil the highest in creasing total soil microorganisms.

SMBC decreased 90 DAP of corn. It was that the soil poppulation of microorganisms was suggested. In the phase, the most microbial population began to be death because they lacked nutrients as their energy will lead to a decrease in the number of microbes. In this phase number of death the cell count of the dead more than the living cell (Volk and Wheeler, 1993).

Correlation betweensoil Respiration and SMBC on some soil progreshes and Total N, P, and K of corn seed

The results of correlation between soil respiration and SMBC by soil organic-C, total N, temperature, soil pH, available-P, total N, P, and K of maize seeds are presented in Table 9.

There was significance between total N, P, and K of maize seeds and soil respiration (Table 9). The research of Yupitasari (2013) in the second growing season (rainy season) showed that a combination of fertilizer Organonitrophos with inorganic fertilizers with a dose of 100 kg ha^{-1}, urea 50 kg SP-36 ha^{-1}, 50 kg ha^{-1}, KCl 1,000 kg ha^{-1} Organonitrophos significantly improve plant, highes number of branches, uptake of N, P, and K of plant and fruit, and the yield of tomato plants. Furthermore, there was significance correlation between with SMBC organic-C available-P, and soil pH (Table 9).

Table 9. The coefficient correlation between the soil properties with by 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 soil SMBC	0.45 ^{ns}
pH and soil respiration	0.49^{ns}
pH and soil SMBC	0.60*
Soil temperatureand soil respiration	-0.18^{ns}
Total-N and soil respiration	0.90*
Total-P and soil respiration	0.88*
Total-K and soil respiration	0.87*
Available-Pwithsoil SMBC	0.69*
Soil Water content and soil SMBC	0.41 ^{ns}
Soil temperature andSMBC	-0.27 ^{ns}

* =significance at P<0,05, ** = significance at P<0,01, ns = non significance

This shows 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 plant. Nutrient source of P was derived from Organonitrophos fertilizers which contained a very high P nutrients namely 3.4% and it was derived from SP-36 fertilizer.

CONCLUSIONS

At the beginning of the corn plant growth, soil respiration decreased up to15 DAP. Then, the soil respiration increased up to 60 DAP of corn plants and there after it decreased again up to 90 DAP of corn plants. Dynamics of soil respiration were not different between the biochar application.

SMBC during the growth of corn plant sgenerally has increased with the increasing doses of organonitrophos fertilizer SMBC with the biochar application of 5000 kg ha^{-1} (B_1) was higher than without biochar (B_0).

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