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Short Communication

Effect of sources of biochar on soil biological properties in an acidic *Alfisols*

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Use of biochar in agricultural systems is one viable option that can enhance natural rates of carbon sequestration in the soil, reduce farm waste and improve the soil quality. It is a stable form of carbon that is created by heating the biomass in a controlled i,e. in a low or no oxygen environment. It is used as a soil amendment because of the extremely porous carbon structure of biochar that helps in effective water and nutrient storage and it also provide a habitat for large number of soil microbes (Sohi *et al.* 2013). Thus in Odisha, there is an immense scope for converting millions of tonnes of crop residues like paddy straw, paddy husk, maize cob, maize stover, arhar stover, etc which are not used as fodder but can be converted into biochar and the same can be used for enriching soil carbon and soil health. Research work on production of biochar from different sources of biomass and its characterization and the benefits of its application to field crops and soil properties are scanty. However, this being an emerging topic, there is a need for more research on production of biochar from different crop residues, their characterization and impact assessment on different soil properties. Keeping these points in mind the present work is framed to study the effect of sources of biochar on soil biological properties in an acidic *Alfisols*.

A tank biochar production unit was established and an incubation study was conducted in the year 2019 at Department of Soil Science and Agricultural Chemistry, Odisha University of Agriculture and Technology, Bhubaneswar, Odisha. The soil for the incubation study was collected from University farm having GPS location 20˚ 15.88' N, 085˚ 48.54' E, 25.9 MSL. The initial soil was *Alfisols* in order, sandy loam in texture, pH (5.02), organic carbon (4.2 g kg^{-1}), mineralizable N (112.5 kg ha^{-1}), Bray's P (11.0 kg ha^{-1}), and NH_4OAc extractable K (191.5 kg ha^{-1}). The collected soil was air dried and processed through a 2mm sieve. The finished product of biochar produced (paddy straw, paddy husk, maize stover, maize cob and arhar stover) was mixed properly with the soil as per the treatments.

The treatments were T1: Control (only soil), T2: Paddy straw biochar @ 1% of soil weight, T3: Paddy husk biochar @ 1% of soil weight, T4: Maize stover biochar @ 1% of soil weight, T5: Maize cob biochar @ 1% of soil weight, T6: Arhar stover biochar @ 1% of soil weight, T7: Paddy straw biochar @ 2% of soil weight, T8: Paddy husk biochar @ 2% of soil weight, T9: Maize stover biochar @ 2% of soil weight, T10: Maize cob biochar @ 2% of soil weight and T11: Arhar stover biochar @ 2% of soil weight. After proper mixing the soil with biochar, the moisture content was maintained at 60 % water holding capacity. At regular interval the moisture content was checked and required amount of water was added to maintain the water holding capacity of the treated soil samples till the last day of incubation. Different observations on soil biological properties of the biochar incubated soil samples were taken at 15 days intervals viz., 15, 30, 45 and 60 days after incubation. Biochar at the rate of 1% and 2% of soil weight was mixed with soil and incubated for analysing different biological properties by adopting standard methods like population of bacteria (nutrient agar medium), fungi (Martins Rose Bengal Agar media), actinomycetes (Khusters nutrient agar media) and soil dehydrogenase activity (Casida *et al.,* 1964) of incubated soil. The analysis of variance (ANOVA) of different variables of different treatments was statistically calculated (Panse and Sukhatme, 1985).

Application of sources of biochar in soil increased the bacterial population (Table 1). The mean value of bacterial population due to application of different sources of biochar in soil varied from 4.52×10^5 cfu g^{-1} soil to 5.65×10^5 cfu g^{-1} soil. The treatment T10 (soil + maize cob

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biochar @2%) had the highest bacterial population of 5.65 × 10^5 cfu g^{-1} soil and the lowest value in treatment T2 (soil + paddy straw biochar @1%) with a mean value of 5.26 × 10^5 cfu g^{-1} soil. Irrespective of sources of biochar, a stimulating response was recorded in soil bacterial population over the days of incubation. The similar result was also found by Zhang *et al* (2018).

Table 1: Effect of different sources of biochar on bacterial (cfu × 10^5 g^{-1} soil) and fungal (cfu × 10^4 g^{-1} soil) population in soil

Treatments	Bacterial population					Fungal population				
	Days after incubation					Days after incubation				
	15	30	45	60	Mean	15	30	45	60	Mean
T1	4.77	4.52	4.43	4.36	4.52	6.23	6.32	6.37	6.35	6.31
T2	4.97	5.30	5.40	5.39	5.26	5.82	5.81	5.78	5.68	5.77
T3	5.05	5.30	5.37	5.36	5.27	5.68	5.64	5.61	5.57	5.62
T4	5.10	5.47	5.54	5.52	5.40	5.76	5.73	5.72	5.68	5.72
T5	5.18	5.30	5.39	5.39	5.31	5.81	5.78	5.74	5.71	5.76
T6	5.13	5.55	5.60	5.63	5.47	5.82	5.78	5.76	5.73	5.77
T7	5.26	5.59	5.65	5.68	5.54	5.11	5.04	5.00	4.96	5.02
T8	5.22	5.71	5.74	5.78	5.61	5.64	5.59	5.56	5.50	5.57
T9	5.26	5.63	5.68	5.68	5.56	5.78	5.74	5.74	5.68	5.73
T10	5.30	5.75	5.78	5.78	5.65	5.52	5.51	5.51	5.42	5.49
T11	5.22	5.71	5.75	5.77	5.61	5.62	5.60	5.58	5.53	5.58
$S.E_m(\pm)$	0.06	0.09	0.05	0.04		0.02	0.04	0.04	0.10	
LSD (p= 0.05)	0.19	0.27	0.17	0.12		0.08	0.12	0.14	0.31	
Initial value					4.50					6.19

T1- Control; T2- Paddy straw biochar@1% of soil weight; T3- Paddy husk biochar@1% of soil weight; T4- Maize stover biochar@1% of soil weight; T5- Maize cob biochar@1% of soil weight; T6- Arhar stover biochar@1% of soil weight; T7- Paddy straw biochar@2% of soil weight; T8- Paddy husk biochar@2% of soil weight ;T9- Maize stover biochar@2% of soil weight; T10- Maize cob biochar@2% of soil weight; T11- Arhar stover biochar@ 2% of soil weight

The fungal population of the soil decreased with application of biochar (Table 1). The result was in contrast to the soil bacterial population. Interestingly, the result showed that the mean fungal population in soil was found to be lowest in treatment T7 (soil + paddy straw biochar@2%) with a mean value of 5.02 × 10^4 cfu g^{-1} soil. However, the highest fungal population was observed in treatment T2 (soil + paddy straw biochar@1%) with a mean value of 5.77× 10^4 cfu g^{-1} soil. By applying biochar, the medium becomes less acidic and tends towards neutrality or slight alkaline medium. This may lead to the decrease in the fungal population (Zhang *et al.,* 2018). Hence in the biochar treated soil an inhibiting response was recorded in fungal population. With addition of biochar to soil, the actinomycetes population was higher in all the treatments as compared to the initial soil. The actinomycetes population in different treatments varied from 2.08 × 10^4 cfu g^{-1} soil to 2.38 × 10^4 cfu g^{-1} soil. In treatment T10 (soil + maize cob biochar@2%), the actinomycetes population was highest (2.38 × 10^4 cfu g^{-1} soil) and lowest in treatment T2 (soil + paddy straw biochar@1%) which was 2.17 × 10^4 cfu × 10^4 g^{-1} soil. Zhang *et al.* (2018) found a similar result regarding the actinomycetes population. However, both stimulating and inhibiting effect was recorded in soil actinomycetes population over the period of incubation.

Soil enzymes activity study is considered as an important tool to assess the nutrient transformation, availability and biological activity of soil vis-à-vis climate change strategies (Panda and Raha, 2015; Panda and Raha, 2016; Panda *et al.,* 2018). The effect of different sources of biochar (a cabon rich substance) had a stimulating effect on soil dehydrogenase enzyme activity (table 2). It was noticed that the DHA was higher in biochar treated soils as compared to the control and it varied from 0.08 to 0.19 mg TPF g^{-1} soil h^{-1} in different biochar treated soil samples. However the treatment T9 (soil + maize stover biochar@2%) and T10 (soil + maize cob biochar @2%) had a significantly higher value of DHA (0.19 mg TPF g^{-1} soil h^{-1}). Among the sources of biochar, maize stover biochar had a stimulating response over other sources biochar used. A non significant variation

was also recorded over the period of incubation. Similar result was also observed by Ouyang *et al.,* (2014), Gregory *et al.,* (2014) and Bhaduri *et al.,* (2016).

Table 2: Effect of different sources of biochar on actinomycetes population (cfu × 10^4 g^{-1} soil) and dehydrogenase activity (mgTPF g^{-1} soil h^{-1}) in soil

Treatments	Actinomycetes population					Soil dehydrogenase activity				
	Days after incubation					Days after incubation				
	15	30	45	60	Mean	15	30	45	60	Mean
T1	2.12	2.06	2.08	2.07	2.08	0.10	0.08	0.09	0.06	0.08
T2	2.16	2.17	2.18	2.18	2.17	0.11	0.12	0.13	0.14	0.12
T3	2.17	2.19	2.20	2.18	2.18	0.13	0.13	0.12	0.11	0.12
T4	2.25	2.29	2.33	2.33	2.30	0.11	0.12	0.14	0.15	0.13
T5	2.27	2.31	2.28	2.31	2.29	0.12	0.14	0.15	0.17	0.14
T6	2.29	2.31	2.30	2.31	2.30	0.14	0.15	0.18	0.19	0.16
T7	2.33	2.35	2.36	2.36	2.35	0.15	0.17	0.19	0.18	0.17
T8	2.32	2.34	2.36	2.38	2.35	0.14	0.16	0.18	0.20	0.17
T9	2.30	2.32	2.35	2.37	2.33	0.16	0.19	0.22	0.21	0.19
T10	2.36	2.37	2.39	2.40	2.38	0.17	0.20	0.21	0.20	0.19
T11	2.31	2.33	2.34	2.35	2.33	0.15	0.18	0.20	0.21	0.18
$S.E_m(\pm)$	0.03	0.03	0.03	0.01		0.01	0.02	0.01	0.02	
LSD (p= 0.05)	0.09	0.10	0.10	0.05		0.04	0.05	0.05	0.07	
Initial value					2.10					0.11

From the present study it may be concluded that application of different sources of biochar showed a positive response towards the microbial activity in soil. Application of maize cob biochar had stimulating effect on soil bacterial and actinomycetes population. It also stimulated the dehydrogenase enzyme activity in soil. In contrast, the fungal population in soil was decreased by applying different sources of biochar. The incubation period had both stimulating and inhibiting effect on soil biological properties.

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