



P-ISSN: 2349-8528

E-ISSN: 2321-4902

www.chemijournal.com

IJCS 2020; 8(2): 708-712

© 2020 IJCS

Received: 13-01-2020

Accepted: 15-02-2020

A Karthik

Ph.D. Scholars, Department of
Agronomy, Tamil Nadu
Agricultural University,
Coimbatore, Tamil Nadu, India

M Uma Maheswari

Ph.D. Scholars, Department of
Agronomy, Tamil Nadu
Agricultural University,
Coimbatore, Tamil Nadu, India

Effect of different biochars on soil moisture retention and nutrient release pattern

A Karthik and M Uma Maheswari

DOI: <https://doi.org/10.22271/chemi.2020.v8.i2k.8850>

Abstract

Soil incubation study in pots was carried out to study the effect of three different biochars on soil moisture retention percentage. The treatments involve three doses of maize biochar (MB), cotton biochar (CB) and prosopis biochar (PB) @ 2.0 t ha⁻¹ (2T), 3.0 t ha⁻¹ (3T) and 4.0 t ha⁻¹ (4T), respectively besides a control and Farm Yard Manure @ 12.5 t ha⁻¹. Significantly higher moisture per cent was noted in treatments of higher doses of all the biochars in second and third day of incubation. The significant increase in moisture per cent was noted in PB 4 T incubated pot, which was followed by CB 4T. The reduction in moisture per cent was noted with lower doses of biochar irrespective of source. Results of another incubation study with different biochars with varied doses, to find out nutrient release pattern revealed that the available N, P and K was higher at the start of incubation in control, where as in later days of incubation N, P and K availability was higher in Prosopis Biochar 4T after 70 days of incubation which was followed by cotton biochar 4T.

Keywords: Biochars, incubation study, soil moisture retention, nutrient release pattern

Introduction

There is an urged need to improve the soil health and quality in sustainable manner along with attaining higher yield of crops. The entry of biochar, a carbon rich material produced through pyrolysis has been studied at smaller scales showing profound effectiveness in improving moisture retention and nutrient release of soil in sustainable manner in order to increase crop yield. The experiment was carried out to study the effect of three different biochars on soil moisture retention (Singh *et al.*, 2012) ^[14]. Most of the crop and agroforestry residues from rainfed areas are burnt in the field due to difficulties in disposing the heavy residues creating a necessity for biochar production (Venkatesh *et al.*, 2018) ^[18]. Biochar can be produced from agricultural residues and by products which cannot fetch monetary return like cobs of maize and pearl millet, stalks from cotton and maize, straws from rice and wheat, along with agro-industrial waste like paper mill waste, jatropha husk, coffee husk, coconut shell and cocoa pod husk can be effectively utilized for the preparation of biochar (Purakayastha *et al.*, 2015) ^[11]. Biochar application results in decrease in soil bulk density, increasing soil fertility and structure, improved water holding capacity, organic carbon content, availability of nutrients and biological properties (Berihun *et al.*, 2017) ^[1]. Moreover, it also serves as a better alternate for other organic manures as it does similar work as that of FYM and other composts, but, in a compact and effective way yielding earlier crop response. The current study has been formulated in order to evaluate the effect of different sources of biochar supplied in different doses on the soil moisture retention and nutrient release pattern.

Materials and Methods

Two experiments were conducted with different source of biochars with various doses. The treatments involve three doses of maize biochar (MB), cotton biochar (CB) and prosopis biochar (PB) @ 2.0 t/ha (2T), 3.0 t/ha (3T) and 4.0 t/ha (4T), respectively besides a control and Farm Yard Manure @ 12.5 t/ha.

(i) Pot culture study for Soil Moisture retention

The experiment was carried out to study the effect of three different biochars on soil moisture retention. Soil from field experimental site was used for the incubation study.

Corresponding Author:**A Karthik**

Ph.D. Scholars, Department of
Agronomy, Tamil Nadu
Agricultural University,
Coimbatore, Tamil Nadu, India

A known weight of air dried soil was taken (10.0 kg) in a plastic pot and imposed with different treatments. The treatment structure comprised similar to that of field experiments i.e. different source of biochars with different doses and replicated three times. The biochars were thoroughly mixed with soil and known quantity of water was added to bring the soil to saturation condition. Moisture percentage was observed at 15 cm depth through moisture meter on daily basis up to 12 days.

(ii) Incubation study for nutrient release pattern

Incubation study was conducted in the pot with incorporation of three sources and doses of biochars planned for field study with three replications. The treatments were imposed without

recommended dose of fertilizers to all the pots. The aim of the study was to find the changes in available nutrients especially N, P and K after incorporation of biochar. The pot was filled with same soil collected from the experimental site after removing the pebbles and debris. Based on the weight of soil, biochar requirement was calculated, weighed and thoroughly mixed with the soil in each pot and incubated. After incubation, soil samples were collected from each replication with an interval of ten days and analyzed for the nutrient status. The study was terminated when the release attained a static phase. The methods used to analyse the soil chemical properties are given in Table 1. The initial soil sample contain available N of 165 Kg ha⁻¹, available P of 10.9 Kg ha⁻¹ and available K of 765 Kg ha⁻¹.

Table 1: Methods used for analysis of chemical properties of soil.

Parameters	Methods	Authors
Organic carbon (%)	Chromic acid wet Digestion	Walkley and Black (1934)
Available Nitrogen (kg ha ⁻¹)	Alkaline permanganate	Subbiah and Asija (1956)
Available Phosphorus (kg ha ⁻¹)	0.5 M Sodium bicarbonate	Olsen (1954)
Available Potassium (kg ha ⁻¹)	Flame photometry	Stanford and English (1949)

Results and Discussion

(i) Pot culture study for soil moisture retention

The soil moisture per cent recorded at first day was insignificant and thereafter significant difference was observed between biochar amended pots and control. Significantly higher moisture per cent was noted in treatments of higher doses of all the biochars in second and third day of incubation. The reduction in moisture per cent was noted with lower doses of biochar irrespective of source. PB 3T, PB 4T and CB 4T are comparable and showed superiority over the rest of the treatments. Lowest moisture per cent was recorded in control during all the days of incubation (Table 2). The PB 4T at 12 DAI showed conspicuously greater moisture percentage over all the treatments. This was followed by PB 3T and CB 4T. This might be due to larger pore size and porosity of PB and CB which hold moisture at higher rates than other biochar and control pots. This is in line confirmation with Speratti (2017) [13]. Increased soil moisture content due to biochar addition was also reported by Ojeda *et al.* (2015) [8] and Gururaj and Krishna (2016) [7].

(ii) Incubation study for nutrient release pattern

The different sources of biochar at specified rates were incubated with the soil. The soil samples collected at fixed intervals were analyzed under laboratory and the results obtained on availability of nitrogen, phosphorus, potassium and organic carbon are presented below.

Available nitrogen

The results recorded during incubation study on available nitrogen showed significant difference among the sources and doses of biochar incorporated with the soil (Table 3). Available N at the start of incubation in the control treatment was found to be significantly higher. The lowest N availability was registered in PB 4T. The available N in the control was in increasing trend up to 20 DAI and thereafter there was gradual depletion up to 70 DAI. In all the biochar treatments irrespective of the types and quantity of application, N availability was in increasing trend up to 70 DAI and significantly highest in PB 4T at 70 DAI. This was on par with CB 4T. FYM 12.5T also shared similar trend of biochar. The nitrogen availability was reduced with the application of biochar during the initial days of incubation

whereas maximum availability was observed in control. The N availability was reduced in PB 4T up to 20 days. The reduction in N availability might be due to greater immobilization in biochar added to soil as the biochar had higher C:N ratio and other reason being as biochar has the ability to adsorb NH₄⁺ ions in larger quantity resulting in reduction of available soil N as pointed out by Beusch *et al.* (2019) [2]. The increased N availability under control pot could be the presence of organic matter in native soil along with more population of active microbes and mineralization process increased the available N as evidenced by Gupta and Kua (2017) [6].

After 30 days of incubation, the N availability started to increase in biochar amended pots and decreased in control drastically. The increased trend was maintained up to 70 days of incubation. The significantly increased N availability in biochar amended pots especially PB 4T which was comparable with CB 4T might be due to slow release of adsorbed ions from biochar as it has the ability to hold large amount ions in its pore space and return back to soil through cation exchange process. The possible reason could be presence of microbes on biochar pores facilitated mineralization process resulted in increased N availability. Xu *et al.* (2016) [20] also reported similar findings.

Available phosphorus

The soil available P significantly varied among different biochar treatments during incubation at different days of intervals (Table 4). The soil available P was increased with PB 4T and was comparable with CB 4T and MB 4T. The available P content was the lowest in control throughout the incubation among the treatments. The soil available P was increasing in all the treatments up to 40 days and it was shown decreasing trend thereafter irrespective of doses and source of biochar. However, the quantity available was the highest in PB 4T throughout the incubation period and this was similar to that of MB 4T and CB 4T. The lowest soil available potassium was observed in control during all the stages of incubation. Significant and progressive increase in the available phosphorus (P) content of the biochar amended soil with increasing the duration of incubation till the 40 days was observed. The concentration of available P was higher in soil amended with PB at 4T during the period of incubation.

The effect of biochar levels, on available phosphorus content was higher in PB 4T but on par with CB 4T at all levels of biochar application and it increased with increasing periods of incubation. The increase in P availability could be due to the release of soluble P directly from biochar and high ion exchange capacity of biochar which may alter P availability by influencing the activity of cations like Ca, Mg, Al and Fe that interact with P.

The increase in P availability might be also due to solubilization of fixed P in the soil by P solubilizing microbes present in the soil and population of such microorganism were multiplied by biochar as it supplies carbon as food source as reported by Deb *et al.* (2016) [5]. Biochar also influenced the bioavailability of P through several other mechanisms associated with P precipitation, such as biochar-induced surface sorption of chelating organic molecules. Biochar has an exceptionally good surface for sorbing polar or non-polar organic molecules across a wide range of molecular mass as viewed by Sudhakar and Dikshit (1999) [17]; Schmidt and Noack (2000) [12]; Preston and Schmidt (2006) [10] and Bornemann *et al.* (2007) [3]. The lowest available P content was observed in control.

Available potassium

Application of biochar at different doses significantly influenced soil available K. The availability of K was higher under PB 4T which was comparable throughout the incubation period with CB 4T besides PB 3T at later stages of 50, 60 and 70 DAI. (Table 5). The available potassium (K) content of biochar incorporated soil was significantly influenced with incubation periods up to 70 days. This might be due to increase in the biochar induced K transformation in the soil. The rate of biochar had a highly significant effect on

the available potassium content at all periods of incubation. At 70 DAI, the available K in PB 4T was the highest but it was similar to that in PB 3T and CB 4T. The lowest available K was recorded in control. Increase in the rate of biochar application markedly enhanced the K availability as ascribed by Speratti (2017) [13]. The supply of available K in biochar is generally higher and increased K availability as a result of biochar application has also been reported by Cheng *et al.* (2008) [4].

Organic carbon (OC)

Organic carbon content of the soil was significantly influenced by application of different sources of biochar with varied levels (Table 6). The OC content of soil ranged from 4.51 g kg⁻¹ to 5.65 g kg⁻¹ between the treatments immediately after application of biochars. The OC content recorded significantly higher in PB 4T since inception of the incubation and up to 70 DAI and it was on par with CB 4T at all the stages of incubation. The control treatment showed the lowest OC almost throughout incubation. However, it was comparable with lower doses of MB 2T and CB 3T. Soil organic carbon is considered as index of soil fertility and sustainability of agriculture system. The soil properties especially physical, chemical and biological properties improved considerably through organic carbon content of the soil. The OC content was decreased over incubation duration irrespective of treatments. The OC content was superior in PB 4T at 70 DAI, but it was comparable with CB 4T at 70 DAI. This was in accordance with Zimmerman (2010) [21] as he reported reduction in OC content during incubation of raw organic manures over time. The lowest OC was registered in the control.

Table 2: Effect of biochar on soil moisture percentage during the incubation study

Treatment	Incubation period											
	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10	Day 11	Day 12
T ₁ : Control	24.2	21.8	21.5	19.2	16.8	15.2	14.0	13.1	12.1	11.3	10.5	9.9
T ₂ : FYM	24.7	22.4	21.7	19.4	17.1	15.5	14.4	13.4	12.5	11.7	10.9	10.3
T ₃ : MB 2T	24.4	22.2	22.2	20.0	17.8	16.3	15.2	14.4	13.5	12.7	12.0	11.4
T ₄ : MB 3T	25.1	22.9	22.9	20.8	18.6	17.2	16.1	15.2	14.4	13.6	12.9	12.3
T ₅ : MB 4T	25.5	23.4	23.4	21.4	19.3	17.9	16.9	16.0	15.2	14.5	13.8	13.2
T ₆ : CB 2T	24.6	22.4	22.4	20.3	18.1	16.7	15.6	14.7	13.9	13.2	12.4	11.8
T ₇ : CB 3T	25.1	23.0	23.0	21.0	18.9	17.6	16.5	15.7	14.9	14.2	13.5	12.9
T ₈ : CB 4T	25.5	23.5	23.5	21.5	19.6	18.3	17.3	16.5	15.7	15.0	14.4	13.8
T ₉ : PB 2T	24.8	22.8	22.8	20.9	18.9	17.6	16.7	15.9	15.1	14.5	13.8	13.2
T ₁₀ : PB 3T	25.2	23.3	23.3	21.5	19.6	18.4	17.5	16.7	16.0	15.4	14.8	14.2
T ₁₁ : PB 4T	25.6	23.8	23.8	22.0	20.2	19.0	18.1	17.4	16.7	16.1	15.5	15.0
SEd	0.61	0.55	0.53	0.49	0.44	0.41	0.38	0.36	0.34	0.34	0.32	0.30
CD (0.05)	NS	1.15	1.11	1.04	0.93	0.85	0.79	0.75	0.71	0.71	0.67	0.63
T	: t ha ⁻¹	MB	:	Maize biochar			FYM	:	Farm yard manure @ 12.5 t ha ⁻¹			
CB	:	Cotton biochar	PB	:	Prosopis biochar							

Table 3: Effect of biochar on soil available nitrogen (kg ha⁻¹) during the incubation study

Treatment	Incubation period (days)						
	10	20	30	40	50	60	70
T ₁ : Control	168.2	170.4	164.7	161.3	160.0	160.1	160.0
T ₂ : FYM	151.8	150.0	153.5	157.4	158.9	158.8	158.2
T ₃ : MB 2T	152.6	151.6	155.4	158.2	159.1	160.2	160.1
T ₄ : MB 3T	152.4	151.2	153.6	156.4	157.2	161.8	161.7
T ₅ : MB 4T	151.0	149.1	152.9	155.7	156.0	162.7	162.7
T ₆ : CB 2T	151.8	150.0	154.6	157.3	157.9	161.9	162.0
T ₇ : CB 3T	150.4	148.5	155.3	157.1	158.1	163.4	163.0
T ₈ : CB 4T	149.8	147.9	153.7	156.4	157.7	164.1	164.3
T ₉ : PB 2T	150.2	147.1	154.2	156.0	156.9	163.5	163.2
T ₁₀ : PB 3T	148.8	145.0	152.7	154.3	157.2	163.5	163.5

T ₁₁ : PB 4T		146.6	142.0	150.6	152.6	158.2	164.9	165.1
SEd		1.83	2.37	1.17	0.72	0.36	0.62	0.67
CD (0.05)		3.82	4.94	2.44	1.50	0.76	1.29	1.40
T	:	t ha ⁻¹				MB	:	Maize biochar
CB	:	Cotton biochar				PB	:	Prosopis biochar
FYM	:	Farm yard manure @ 12.5 t ha ⁻¹						

Table 4: Effect of biochar on soil available phosphorus (kg ha⁻¹) during the incubation study

Treatment	Incubation period (days)							
	10	20	30	40	50	60	70	
T ₁ : Control	12.22	12.36	12.48	12.54	12.52	12.50	12.49	
T ₂ : FYM	13.28	13.43	13.57	13.63	13.60	13.59	13.58	
T ₃ : MB 2T	13.24	13.39	13.53	13.59	13.56	13.55	13.54	
T ₄ : MB 3T	13.39	13.55	13.68	13.75	13.72	13.71	13.69	
T ₅ : MB 4T	14.44	14.60	14.75	14.81	14.79	14.77	14.76	
T ₆ : CB 2T	13.39	13.55	13.68	13.75	13.72	13.71	13.69	
T ₇ : CB 3T	14.02	14.18	14.32	14.39	14.36	14.35	14.33	
T ₈ : CB 4T	14.37	14.54	14.68	14.75	14.72	14.71	14.70	
T ₉ : PB 2T	13.77	13.93	14.06	14.13	14.10	14.09	14.08	
T ₁₀ : PB 3T	14.19	14.36	14.50	14.57	14.54	14.52	14.51	
T ₁₁ : PB 4T	14.84	15.01	15.16	15.23	15.20	15.19	15.17	
SEd	0.240	0.243	0.244	0.245	0.246	0.243	0.246	
CD (0.05)	0.501	0.507	0.509	0.511	0.512	0.510	0.513	
T	:	t ha ⁻¹				MB	:	Maize biochar
CB	:	Cotton biochar				PB	:	Prosopis biochar
FYM	:	Farm yard manure @ 12.5 t ha ⁻¹						

Table 5: Effect of biochar on soil available potassium (kg ha⁻¹) during the incubation study

Treatment	Incubation period (days)								
	10	20	30	40	50	60	70		
T ₁ : Control	761.6	763.9	767.8	769.1	768.1	767.1	767.8		
T ₂ : FYM	768.9	772.3	776.6	777.8	778.2	777.1	777.9		
T ₃ : MB 2T	765.2	768.6	772.8	774.1	778.5	777.5	778.3		
T ₄ : MB 3T	769.2	772.7	777.0	778.2	782.8	781.7	782.5		
T ₅ : MB 4T	774.7	779.3	784.0	785.3	790.2	789.0	789.9		
T ₆ : CB 2T	770.8	774.3	778.6	779.8	784.4	783.3	784.1		
T ₇ : CB 3T	774.6	778.7	783.2	784.6	789.3	788.1	789.0		
T ₈ : CB 4T	779.6	784.2	788.8	790.1	795.0	793.8	794.7		
T ₉ : PB 2T	770.4	774.3	778.7	780.0	784.6	783.5	784.3		
T ₁₀ : PB 3T	777.5	781.8	786.3	787.7	792.5	791.3	792.1		
T ₁₁ : PB 4T	782.2	787.2	792.0	793.4	798.4	797.2	798.0		
SEd	2.02	2.25	2.32	2.34	2.83	2.81	2.83		
CD (0.05)	4.21	4.70	4.85	4.87	5.92	5.88	5.90		
T	:	t ha ⁻¹					MB	:	Maize biochar
CB	:	Cotton biochar					PB	:	Prosopis biochar
FYM	:	Farm yard manure @ 12.5 t ha ⁻¹							

Table 6: Effect of biochar on soil organic carbon (g kg⁻¹) during the incubation study

Treatment	Incubation period (days)							
	10	20	30	40	50	60	70	
T ₁ : Control	4.52	4.50	4.48	4.46	4.44	4.42	4.41	
T ₂ : FYM	5.00	4.97	4.95	4.93	4.91	4.89	4.89	
T ₃ : MB 2T	4.56	4.52	4.49	4.47	4.45	4.41	4.42	
T ₄ : MB 3T	4.76	4.67	4.65	4.63	4.61	4.57	4.56	
T ₅ : MB 4T	5.02	4.87	4.82	4.80	4.78	4.74	4.74	
T ₆ : CB 2T	4.59	4.52	4.50	4.48	4.46	4.44	4.44	
T ₇ : CB 3T	4.80	4.65	4.61	4.59	4.57	4.55	4.54	
T ₈ : CB 4T	5.49	5.31	5.29	5.27	5.25	5.20	5.21	
T ₉ : PB 2T	4.91	4.76	4.75	4.73	4.71	4.66	4.67	
T ₁₀ : PB 3T	5.34	5.10	5.08	5.06	5.04	4.99	4.98	
T ₁₁ : PB 4T	5.62	5.36	5.34	5.32	5.30	5.25	5.25	
SEd	0.124	0.100	0.102	0.102	0.101	0.099	0.098	
CD (0.05)	0.259	0.209	0.213	0.213	0.212	0.207	0.206	
T	:	t ha ⁻¹				MB	:	Maize biochar
CB	:	Cotton biochar				PB	:	Prosopis biochar
FYM	:	Farm vard manure @ 12.5 t ha ⁻¹						

References

1. Berihun T, Tolosa S, Tadele M, Kebede F. Effect of biochar application on growth of garden pea (*Pisum sativum* L.) in acidic soils of Bule Woreda Gedeo Zone southern Ethiopia. *International Journal of Agronomy* 2017. <https://doi.org/10.1155/2017/6827323>
2. Beusch C, Cierjacks A, Böhm J, Mertens J, Bischoff WA, JC de Araújo Filho *et al.* Biochar vs. clay: Comparison of their effects on nutrient retention of a tropical Arenosol. *Geoderma*. 2019; 337:524-535.
3. Bornemann LC, Kookana RS, Welp G. Differential sorption behaviour of aromatic hydrocarbons on charcoals prepared at different temperatures from grass and wood. *Chemosphere*. 2007; 67(5):1033-1042.
4. Cheng CH, Lehmann J, Engelhard MH. Natural oxidation of black carbon in soils: changes in molecular form and surface charge along a climosequence. *Geochimica et Cosmochimica Acta*. 2008; 72(6):1598-1610.
5. Deb D, Kloft M, Lässig J, Walsh S. Variable effects of biochar and P solubilizing microbes on crop productivity in different soil conditions. *Agroecology and Sustainable Food Systems*. 2016; 40(2):145-168.
6. Gupta S, Kua HW. Factors determining the potential of biochar as a carbon capturing and sequestering construction material: critical review. *Journal of Materials in Civil Engineering* 29 (9):04017086.
7. Gururaj SB, Krishna B. Water retention capacity of biochar blended soils. *Journal of Chemical and Pharmaceutical Sciences*. 2016; 9(3):1438-1441.
8. Ojeda G, Mattana S, Avila A, Alcariz JM, Volkmann M, Bachmann J. Are soil-water functions affected by biochar application? *Geoderma*. 2015; 249:1-11.
9. Olsen S. Estimation of available phosphorus in soils by extraction with sodium bicarbonate, United States Department of Agriculture; Washington. 1954; 939:1-19
10. Preston C, Schmidt M. Black (pyrogenic) carbon: a synthesis of current knowledge and uncertainties with special consideration of boreal regions. *Biogeoscience*. 2006; 3: 397-420.
11. Purakayastha T, Kumari S, Pathak H. Characterisation, stability, and microbial effects of four biochars produced from crop residues. *Geoderma*. 2015; 239:293-303.
12. Schmidt MW, AG Noack. Black carbon in soils and sediments: analysis, distribution, implications, and current challenges. *Global Biogeochemical Cycles*. 2000; 14(3):777-793.
13. Speratti AB. Biochar for the Brazilian Cerrado: contributions to soil quality and plant growth. Thesis, The University of British Columbia, 2017.
14. Singh BP, Cowie AL, Smernik RJ. Biochar carbon stability in a clayey soil as a function of feedstock and pyrolysis temperature. *Environmental Science and Technology*. 2012; 46(21):11770-11778.
15. Stanford G, English L. Use of the flame photometer in rapid soil tests for K and Ca. *Agronomy Journal*. 1949; 41(9):446-447.
16. Subbiah B, Asija G. Alkaline permanganate method. *Current Science*. 1956; 25:258-260.
17. Sudhakar Y, Dikshit A. Kinetics of endosulfan sorption on to wood charcoal. *Journal of Environmental Science and Health Part B*. 1999; 34(4):587-615.
18. Venkatesh G, Gopinath K, Sammi Reddy K, Sanjeeva Reddy B, Prasad J *et al.* Biochar production and its use in rainfed agriculture: Experiences from CRIDA. *CRIDA-NICRA Research Bulletin*. 2018; 2(2018):50.
19. Walkley A, IA Black. An examination of the Degtjareff method for determining soil organic matter, and a proposed modification of the chromic acid titration method. *Soil Science*. 1934; 37(1):29-38.
20. Xu P, CX Sun, XZ Ye, WD Xiao, Q Zhang, Q Wang. The effect of biochar and crop straws on heavy metal bioavailability and plant accumulation in a Cd and Pb polluted soil. *Ecotoxicology and Environmental Safety*. 2016; 132:94-100.
21. Zimmerman AR. Abiotic and microbial oxidation of laboratory-produced black carbon (biochar). *Environmental Science and Technology*. 2010 44(4):1295-1301.