Effect of Biochar Soil Amendment on Soil Properties and Yield of Sesame Varieties in Lafia, Nigeria

Article *in* American Journal of Experimental Agriculture · January 2015

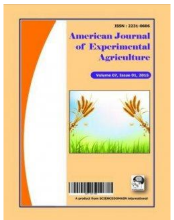
DOI: 10.9734/AJEA/2015/19637

3 authors:

E. Ndor
College of Agriculture Lafia, Nasarawa State; Nigeria

James Olumuyiwa Jayeoba
Nasarawa State University

Charles L.A. Asadu
University of Nigeria



American Journal of Experimental Agriculture
9(4): 1-8, 2015, Article no.AJEA.19637
ISSN: 2231-0606

SCIENCEDOMAIN *international*
www.sciencedomain.org

SCIENCEDOMAIN

Effect of Biochar Soil Amendment on Soil Properties and Yield of Sesame Varieties in Lafia, Nigeria

E. Ndor[1*], O. J. Jayeoba[2] and C. L. A. Asadu[3]

[1]*Department of Crop Production Technology, College of Agriculture, Lafia, Nasarawa State, Nigeria.*
[2]*Department of Agronomy, Faculty of Agriculture, Nasarawa State University, Shabu-Lafia, Nigeria.*
[3]*Department of Soil Science, University of Nigeria, Nsukka, Nigeria.*

Authors' contributions

This work was carried out in collaboration between all authors. Author EN designed the study, wrote the protocol and wrote the first draft of the manuscript. Author CLAA reviewed the experimental design and all drafts of the manuscript. Author CLAA managed the analyses of the study. Author OJJ identified the plants. Authors OJJ and EN performed the statistical analysis. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJEA/2015/19637
Editor(s):
(1) Rusu Teodor, Department of Technical and Soil Sciences, University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca, Romania.
Reviewers:
(1) Klara Kosova, Crop Research Institute, Prague, Czech Republic.
(2) Kwong Fai Andrew Lo, Chinese Culture University, Taiwan.
Complete Peer review History: http://sciencedomain.org/review-history/10609

Original Research Article

Received 20th June 2015
Accepted 21st July 2015
Published 19th August 2015

ABSTRACT

The experiments were conducted during 2011 and 2012 rainy season at the research and teaching farm of the college of agriculture, Lafia, Nasarawa state, Nigeria; to evaluate the effect of biochar amended soil on soil properties and yield of sesame varieties. The treatments consisted of three rates of rice husk biochar (0, 5 and 10 t/ha) and three rates of sawdust biochar (0, 5 and 10 t/ha) and two varieties of sesame (Yandev 55 and local variety) which were factorially combined and laid in a Randomized Complete Block Design (RCBD) and replicated three times. The result showed that the soil is low in major nutrients before the incorporation of biochar. The soil was also acidic in nature (pH: 5.98). After incorporation of biochar and two y ears of cropping. Result revealed that both rice husk and sawdust biochars rates did not showed any significant effect on sand, clay and silt; but had a significant effect on % soil moisture content, bulk density, % porosity and % soil water-filled pore space. Application of 10 t/ha produced the highest value of 10.697% and 10.77% soil moisture content, 36.47% and 35.58% of soil porosity, 50% and 50.6% soil water

**Corresponding author: E-mail: ndors12@yahoo.com;*

filled pore space in both rice husk and sawdust biochar. This is at par with application of 5 t/ha of both biochars, but it is higher than the control treatment. However, bulk density decreases with increased rates of biochar application. Therefore, the control produced soils with the higher bulk density of 1.67 g/cm^3 and 1.69 g/cm^3 with rice husk and sawdust biochar respectively. Also, Rice husk and sawdust biochars rates had a significant effect on all the chemical properties in the soil. 10 t/ha of rice husk and sawdust biochar produced the highest levels of pH, = 6.80:6.74; %TN, =0.15: 0.14; K, =0.59: 0.65; %OC, = 0.68:0.75; Mg, = 0.75: 1.14; Na = 0.71:0.79 and CEC= 7.83:8.05, respectively. This is at par with application of 5 t/ha, but higher than the control. Increased biochar application resulted in a gradual increase in all the chemical properties in the soil except H+Al which displayed an opposite trend. Application of 10 t/ha of sawdust and rice husk biochar produced the highest seed weight of 0.93: 0.83 t/ha and 0.90:0.95 t/ha in both years, respectively. This is at par with application of 5 t/ha of both biochars in the two cropping season, but higher than control. Sesame varieties also showed a significant effect in both cropping season; Yandev 55 demonstrated its superiority against the local variety by producing 0.76 t/ha and 0.77 t/ha in 2011 and 2012 cropping season. However, the combine effect of sawdust biochar and rice husk biochar did not produce any significant effect on the soil properties and sesame yield.

Keywords: Biochar; soil; amendment; sesame; yield.

1. INTRODUCTION

Sesame (*Sesamum indicum* L.) belongs to the plant family *Pedaliacea* commonly called beniseed in Nigeria. It is grown in both tropical and sub-tropical regions of Africa, Asia and Latin America. It is the most important crop from which oils are obtained and perhaps the oldest crop cultivated for its oil [1]. Today India & China are the world's biggest producers of sesame followed by Myanmar, Sudan, Uganda, Nigeria, Pakistan, Tanzania, Ethiopia, Guatemala and Turkey [2]. In Nigeria, sesame is produced mainly in the savanna agro-ecological zones by small holders' farmers on relatively poor soils with limited inputs in the following states: Adamawa, FCT Abuja, Benue, Borno, Gombe, Jigawa, Kano, Katsina, Kebbi, Kogi, Nasarawa, Plateau, Taraba and Yobe [3]. However, sesame yields in Nigeria remained very low compared to other countries of the world [4]. This is because sesame is cultivated on marginal and sub-marginal lands with poor fertility, under rainfed conditions without any nutrients management. Survey reports have shown that fertilizers are not applied to sesame even in major sesame growing areas of Nigeria. This view is also upheld by other researchers like [5-9]. Jakusko and Usman [10] listed the following: Poor soil fertility, poor agronomic practice, pest and disease, weed infestation, low yielding cultivars as the major factors that contribute to low yield of sesame in Nigeria. Salako [11] reported a rapid depletion of soil nutrients and poor physical condition of the savanna soils which constitute a strong limitation to crop production in the region. This soil nutrients depletion is a consequence of population pressure which forces farmers to grow crops year after year continuously on same plot of land without application of any soil nutrients restoratives measures. This usually results to "soil mining" or soil nutrients depletion which leads to a decrease in crop yield [12]. Healthy soil contains a mixture of air, water, nutrients and organic matter in a right proportion which is the key for supporting healthy plants [13]. Therefore, every soil has the capacity of becoming a healthy soil, especially when the soil benefit from amendments. Warren [14] defines soil amendment as the use of organic or inorganic materials to improve both the physical and chemical properties of the soil. He also emphasized that the materials chosen for soil amendment must improve the physical properties of the soil such as the water retention, water infiltration, permeability, drainage, structure, and aeration. Because the goal of any soil amendment is to provide a better and more nourishing environment for plant roots. For soil amendment to work, the amendment materials must be thoroughly mixed within the soil. If it is just placed under the soil, it can interfere with movement of water or air and the growth of the plant roots can be affected [15]. International Biochar Initiative (IBI) recommended the use of biochar as a material for soil amendment. Because biochar is a stable form of carbon that can last for hundreds of years in the soil, compare to compost that breaks down so quickly to release nitrous oxide, methane and carbon dioxide into the atmosphere thereby increasing global warming. Biochar is a stable form of charcoal produced from heating natural organic materials (crop biomass, woodchips, manure and other agricultural waste) in a high temperature, low oxygen process known as pyrolysis [16]. The addition of biochar as amendment materials to agricultural soils is receiving much attention due to the apparent benefits of biochar to soil quality and enhanced crop yields, as well as the potential to gain carbon credits by active carbon sequestration [17]. Considering the low yield of sesame obtained in most growing areas as a result of non application of fertilizers and the poor fertility status of savanna soils. This study aimed at evaluating the effect of biochar amended soil on soil properties and yield of sesame.

2. MATERIALS AND METHODS

2.1 Climate Conditions

The experiment was conducted during 2011 and 2012 rainy season at the research and teaching farm of the college of agriculture, Lafia, Nasarawa state, Nigeria. The study area falls within southern guinea savanna agroecological zone of Nigeria, and is located between Latitude 08.33 N and Longitude 08.32 E. Rainfall usually starts from March – October and the average monthly rainfall figures ranges from 40 mm-350 mm. The months of July and August usually records heavy rainfall. The daily maximum temperature ranges from 20.0ºC – 38.5ºC and daily minimum ranges from 18.7ºC – 28.2ºC. The months of February to early April are the months that have the highest maximum temperature while the lowest maximum temperature months are recorded in December and January because of the prevailing cold harmattan wind from the northern part of the country at this period. The relative humidity rises as from April to a maximum of about 75- 90 percent in July [18].

2.2 Soil and Vegetation Conditions

The soil type of the study area composed of highly leached ultisols with low base saturation. The soil is strongly acidic and has high content of iron and Aluminium oxides hence reddish brown in colour with very low organic matter content and low total nitrogen and available phosphate. The vegetation of the study area is that of the southern Guinea Savanna with interspersion of thicket, grassland, trees, fringing woodlands or gallery forest along the streams. The natural vegetation of the area is made up of grasses and some traces of scattered wild and economic trees like *Vittellaria paradoxa* (Shear butter tree); *Parkia* spp (locust bean tree); *Gmelina* arborea (beechwood); *Anacadium* spp (Cashew trees); *Magnifera indica* (Mango). These trees usually shed off their leaves in the long dry season to conserve the available water.

2.3 Experimental Design and Data Collection

The treatments consisted of three levels of rice husk biochar (0, 5 and 10 t/ha) and sawdust biochar (0, 5 and 10 t/ha) and two varieties of sesame (Yandev 55 and local variety) which were factorially combined and laid in a Randomized Complete Block Design (RCBD) and replicated three times to form fifty four plots. The plot size was 3 m by 4 m and 0.5 m between plots and 1 m between replicates.

The soil data for this study were collected from soil samples at the depth of 15 cm from experimental plots were biochar was incorporated and sesame was planted. The biochar of rice husk and sawdust were produced locally through slow burning under limited oxygen condition and incorporated at different rates into the soil. The experimental plots were close to each other within the same climatic region, relief, parent material and soil types. This makes comparison of soil properties between the different biochar types and rates possible. Then each plot was divided into three strata and three composite soil samples were collected from each plot and bulk together to form a bulk soil sample per plot, so that the land will be adequately covered and the soil of the entire land will have equal opportunity to be collected without bias. Core method was also carried out in the field for determination of bulk density of the soil. All the samples were collected after 2 years of cropping the land with sesame.

2.4 Laboratory Analyses

The soil samples were collected air-dried, and thoroughly mixed, then passed through 2 mm sieve mesh to obtain a homogeneous particle sizes, after which standard laboratory procedures as described by [19] was used to determine both physical and chemical properties of these bulk soil samples. The Macro-Kjeldahl method was used to determine the total nitrogen in the soil samples. Available phosphorus was determined using extractable solution of sodium bicarbonate Na $(HCO_3)_2$. (Olsen 1945 method). Exchangeable bases were determined using flame atomic absorption spectrometry and the concentration of potassium was determined using the flame photometer. The organic carbon was determined using the Walkley-Black chromic acid titration method. Soil pH was determined using the electrometric method. Cation exchange capacity (CEC) is determined using ammonium acetate method; that is measuring the total amount of a given cation needed to replace all the cation from a soil exchange site and it is expressed in centimoles per 100 gram soil (Cmol/100 g soil). The moisture holding capacity of the soil was determined using oven drying of soil.

$$\text{Soil moisture content (g/g)} = \frac{\text{(Weight of moist soil - weight of oven dry soil)}}{\text{Weight of oven dry soil}} \quad (1)$$

The bulk density was determined by using core sampler.

$$\text{Soil bulk density (g/cm3)} = \frac{\text{Oven dry weight of soil}}{\text{Volume of soil}} \quad (2)$$

The percent total porosity was computed from the bulk density assuming a particle density of 2.65cm^{-3}.

$$\text{Soil porosity (\%)} = 1 - \frac{\text{Soil bulk density}}{2.65} \quad (3)$$

$$\text{Soil water-filled pore space (\%)} = \frac{\text{Volumetric water content x 100}}{\text{Soil porosity}} \quad (4)$$

Volumetric water content (g/cm^3) = soil moisture content (g/g) x bulk density (g/cm^3).

The data obtained were subjected to analysis of variance (ANOVA) using GENSTAT to determine the significant differences. Where there is a significant difference; the means were separated using F-LSD at 5% probability level.

3. RESULTS AND DISCUSSION

The result of the laboratory analysis of the soil and the biochars (Table 1) showed that the soil is low in nitrogen, phosphorus, potassium and organic carbon. The soil was also acidic in nature (pH: 5.98).

Result of the study in Table 2, revealed that both rice husk and sawdust biochars rates did not showed any significant effect on sand, clay and silt; but had a significant effect on % soil moisture content, bulk density, % porosity and % soil water-filled pore space. Application of 10t/ha produced the highest value of 10.69% and 10.77% soil moisture content, 36.47% and 35.58% of soil porosity, 50% and 50.6% soil water filled pore space in both rice husk and sawdust biochar. This is at par with application of 5t/ha of both biochars, but it is far better than the control treatment. However, bulk density decreases with increased rates of biochar application. Therefore the control produced soils with higher bulk density of 1.67 g/cm^3 and 1.69g/cm^3 with rice husk and sawdust biochar respectively. Interaction between rice husk and sawdust biochar did not produced any significant effects.

The result of biochar soil amendment on chemical properties of soil sampled after two years of sesame production are presented in Table 3. Rice husk and sawdust biochars rates had a significant effect on all the chemical properties in the soil. 10 t/ha of rice husk and sawdust biochar produced the highest levels of pH, = 6.80:6.74; %TN, =0.15: 0.14; K, =0.59: 0.65; %OC, = 0.68:0.75; Mg, = 0.75: 1.14; Na = 0.71:0.79 and CEC= 7.83:8.05, respectively. This is statistically the same with application of 5t/ha but higher than the control. Increased biochar application resulted to a gradual increase in all the chemical properties in the soil except H+Al which showed an opposite trend. Interaction between rice husk and sawdust biochar did not produced any significant effects.

Sawdust and Rice husk biochar showed a significant effect on yield parameter of sesame in 2011 and 2012 cropping season (Table 4). Application of 10 t/ha of sawdust and rice husk biochar produced the highest seed weight of 0.93: 0.83 t/ha and 0.90:0.95 t/ha in both years respectively. This is at par with application of 5 t/ha of both biochars in the two cropping season, but higher than control. Sesame varieties also showed significant effect in both cropping season; Yandev 55 demonstrated its superiority against the local variety by producing 0.76 t/ha and 0.77 t/ha in 2011 and 2012 cropping season. However, interaction between sawdust biochar and rice husk biochar did not produced any significant effect.

4. DISCUSSION

The result in table one showed soil that is already exhausted due to intensive and continuous cultivation without adequate application of replenishment measures to sustain it productivity. This result agrees with finding of [20]. It was also observed that the soil is acidic. This result is in tandem with the research work of [21] who reported that soils around nasarawa state are acidic. Also both rice husk and sawdust biochars contained just small quantities of carbon and carbon / nitrogen ratio. Therefore, this signified that the decomposition of these biochars material will continue at a slower rates and nitrogen will be released for use by crops and other micro organisms in the soil. Biochar incorporation into the soil as soil amendment improved both the physical and chemical properties of soil for crop production. This is in conformity with the work of [22] who reported that Biochar used as a soil amendment, can boost soil fertility and improve soil quality by reducing soil acidity, increasing moisture holding capacity, attracting more beneficial fungi and microbes, improving cation exchange capacity (CEC), and retaining nutrients in soil. Novak et al. [23] also reported that biochar enhances the water retention capacity of soils, thus improving dry or sandy soils and reducing irrigation requirements. The main mechanism behind the increased water holding capacity and improved saturated hydraulic conductivity can be attributed to the

Table 1. Results of laboratory analysis of soil and biochars before cropping

Physical and chemical properties	Soil sample @ 0-15cm	Rice husk biochar	Sawdust biochar
Mechanical composition			
Clay (g/kg)	8.64	ND	ND
Silt	26.21	ND	ND
Sand	65.22	ND	ND
Textural classification (USD)	Sandy loam		
Ash content (%)	Nd	13.56	15.78
Chemical composition			
pH (H2O)	5.98	8.12	8.85
pH (0.01MCaCl2)	5.34	7.52	7.92
T N%	0.13	4.25	3.85
Avail. P(ppm)	15.08	0.54	1.94
K (mg/kg)	0.16	3.63	2.00
OC (mg/kg)	0.42	6.13	6.78
C/N	3.23	1.44	1.76
Mg (mol/kg)	0.49	0.23	0.35
Ca (mol/kg)	4.34	1.34	1.65
Na (mol/kg)	0.85	0.21	0.34
CEC (mol/kg)	4.75	3.21	3.65

ND: Not determined

Table 2. Effect of biochar soil amendment on physical properties of soil

Treatments (Biochars)	% soil particle sizes			% SMC	BD (g/cm^3)	% porosity	% soil water-fill pore space
	Sand	Silt	Clay				
Ricehusk (t/ha)							
0	70.33	13.33	16.33	9.27	1.67	33.26	45.8
5	69.00	15.67	16.33	10.66	1.60	35.38	49.7
10	68.33	14.67	17.67	10.69	1.58	36.47	50.0
Sawdust (t/ha)							
0	69.38	13.30	17.33	9.16	1.69	32.45	48.6
5	67.00	15.67	18.33	10.69	1.62	35.08	50.4
10	67.52	14.45	18.67	10.77	1.60	35.58	50.6
LSD(0.05)	2.24	2.05	2.12	0.29	0.07	2.00	1.23
Interaction							
RHB X SDB	NS	NS	NS	NS	NS	NS	NS

RHB= Ricehusk Biochar; SDB= Sawdust Bioachar; NS= No significant difference; BD= Bulk Density

Table 3. Effect of biochar soil amendment on chemical properties of soil

Treatment	pH ratio		(%)		(ppm)			(Cmol/kg)			
Biochar (t/ha)	H_2O	0.01 $Cacl_2$	OC	TN	Av. P	Ca	Mg	K	Na	H+ Al (Acidity)	CEC
Ricehusk											
0	6.37	6.01	0.54	0.09	23.18	4.47	0.22	0.24	0.49	0.60	5.42
5	6.58	6.46	0.66	0.13	24.35	5.14	0.53	0.42	0.49	0.48	6.58
10	6.80	6.82	0.68	0.15	32.35	5.78	0.75	0.59	0.71	0.37	7.83
Sawdust											
0	6.43	6.04	0.31	0.11	23.76	4.15	0.47	0.24	0.39	0.50	5.25
5	6.58	6.54	0.73	0.12	24.21	4.76	0.69	0.37	0.51	0.49	6.33
10	6.74	6.92	0.75	0.14	32.06	5.47	1.14	0.65	0.79	0.47	8.05
LSD(0.05)	0.23	0.35	0.17	0.02	0.71	0.91	0.17	0.13	0.18	0.19	1.02
Interaction											
RH X SD	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

RHB=Ricehusk Biochar; SDB=Sawdust Bioachar; NS= No significant difference

Table 4. Effect of biochar soil amendment on yield and yield parameters of sesame varieties

Treatment (Biochars)	Number of pods/plant		Fresh pod weight/plant		Seed weight/ plant(g)		Seed weight/ plot(kg)		Seed weight t/ha	
	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012
Sawdust(t/ha)										
0	49.32	54.52	32.23	34.10	4.06	4.49	1.09	1.01	0.64	0.63
5	52.42	56.81	36.96	38.42	4.91	4.97	1.30	1.23	0.83	0.77
10	68.00	71.82	39.10	39.93	5.27	5.78	1.49	1.34	0.93	0.82
Rice husk(t/ha)										
0	53.12	55.34	34.82	33.85	3.84	4.48	0.92	0.90	0.59	0.60
5	58.81	61.53	35.56	35.53	4.89	4.93	1.17	1.18	0.73	0.75
10	63.14	75.85	40.18	43.23	6.06	6.12	1.48	1.46	0.90	0.95
LSD(0.05)	10.94	10.85	4.95	3.42	1.07	1.27	0.21	0.30	0.11	0.12
Sesame varieties										
Local	55.72	59.32	35.05	37.12	4.75	4.77	1.14	1.13	0.72	0.71
Yandev 55	56.87	62.01	37.51	37.83	5.06	5.21	1.24	1.23	0.76	0.77
LSD(0.05)	0.93	0.50	0.85	0.24	0.18	0.13	0.06	0.10	0.02	0.04
Interaction										
SDB X RHB	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

RHB= Ricehusk Biochar; SDB=Sawdust Bioachar; NS= Not significant

modification of the soil's porosity. Sandy soils have low water holding capacities, due to a dominant macro-and meso-pore systems present, with little to no organic material and/ or clay at hand. Bulk density is another key parameter to note, because it is directly affected by the application of biochar. The effect is possibly due to the modification in bulk density; before amendment of soil with biochar, the soil was more compacted and therefore a higher bulk density present, and with biochar amendment the soil strength decreased as the bulk density also decreased. These findings are in consonance with the recent research work by [24] who reported a decrease in soil bulk density after biochar additions, but increases in soil porosity and soil aeration. This may have a positive effect on root and microbial respiration. The significant response of sesame to biochar amended soil increases with application of more biochar rates in the soil. Increased biochar application increases crop yields over the control between 29.9% to 30% from the first year to the second year of cropping. This improvement in yield is a result of incorporation of biochar into the soil which aid in: Soil nutrients improvement, cation exchange capacity in the soil, decrease soil acidity, improve soil structure, nutrient use efficiency, improved water-holding capacity and carbon sequestration. This result corroborate the findings of most recent reviews by [25] who published data from 59 pot experiments and 57 field experiments from 21 countries and found crop productivity was increased by 11% on average. They also discovered that field application of biochar rates of 10 tons/ha reported increases in crop productivity which varied with crop type with greater increases for legume crops (30%), vegetables (29%), and grasses (14%) compared to cereal crops like corn (8%), wheat (11%), and rice (7%).

5. CONCLUSION

In conclusion, the result of this study indicated that soil properties and yield of sesame varieties were significantly influenced by biochar soil amendment. Significantly higher yield were recorded with 10 t/ha of rice husk and sawdust biochar, which is at par with application of 5 t/ha in both 2011 and 2012 cropping seasons. Therefore, 5 t/ha of these biochar materials can be adopted by the farmers in this agroecological zone.

DISCLAIMER

This manuscript was presented in the conference "Soil Science Society of Nigeria Conference 2015" available link is "http://sssn2015.lmu.edu.ng/12th-march-2015/" date 12th March 2015.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Onwueme IC, Sinha TD. Field crop production in tropical Africa: Principles and practice. Technical Centre for Agriculture and Rural Cooperation. Netherlands. 1991;488.
2. Burden D. Sesame Profile; 2005. Available:http//:www.cropprofile.mht (Accessed 15 January, 2008)
3. RMRDC. Report on survey of Agro-raw materials in Nigeria beniseed. Raw Materials Research and Development Council, Abuja. 2004;99.
4. Abubakar SS, Onyibe JE, Tologbonshein EB. The role of extension, research and information dissemination in enhancing beniseed production and marketing for resource poor farmers. Proceedings of the First Workshop on Beniseed held at the National Cereal Research Institute, Badegi, Nigeria, March 3rd–5th. 1998;86-89.
5. Shehu HE, Kwari JD, Sandabe MK. Nitrogen, phosphorus and potassium nutrition of sesame in Mubi, Adamawa state Nigeria. Research Journal of Agronomy. 2009;3(3-4):32-36.
6. Haruna IM. Growth and yield of Sesame (*Sesamum indicum* L.) as affected by poultry manure, nitrogen and phosphorus at Samaru, Nigeria. Journal of Animal & Plant Sciences. 2011;21(4):653-659.
7. Haruna IM, Abimiku MS. Yield of Sesame (*Sesamum indicum* L.) as influenced by organic fertilizers in the Southern Guinea Savanna of Nigeria. Sustainable Agriculture Research. 2012;1:1.
8. Jakusko BB, Usman BD, Mustapha AB. Effect of row spacing on growth and yield of Sesame (*Sesamum indicum* L.) in Yola, Adamawa State, Nigeria. Journal of Agriculture and Veterinary Science. 2013; 2(3):36-39.
9. Iorlamen T, Ayam FM, Akombo RA. Growth and yield response of Sesame (*Sesamum indicum* L.) to foliar and soil applied fertilizer in Makurdi, Benue state. International Journal of Scientific Research and Management (IJSRM). 2014;2: 2528-541.
10. Jakusko BB, Usman BD. Effects of npk fertilizer and plant population density onproductivity of Sesame (*Sesamum indicum* L.). Journal of Agricultural and Environmental Management. 2013;2(5): 121-126.
11. Salako FK. Soil physical conditions in nigerian savannas and biomass production. Department of Soil Science and Agricultural Mechanisation, University of Agriculture, Abeokuta, Nigeria lecture given at the college on soil physics. World Journal of Agricultural Sciences. 2003; 3(4):508-5021.
12. Ndor E, Dauda SN, Azagaku DE. Soil Macro-nutrient dynamics under maize based cropping systems in ultisols of Southern Guinea Savanna, Nigeria. Best Journal; 2013.
13. Anderson R, Wight J, Wright D, Wright M. Soil amendment with biochar for fertility and yield; 2012.
14. Warren TA. Soil Amendments and organic materials. Ezine article; 2010.

Available:http://EzineArticles.com/?expert=Thomas_Arrama_Warren

15. Davis JG, Wilson CR. Choosing a soil amendment. Colorado State University Extension; 2012.
16. Lehmann J, Hanley K, Hyland C, Rajkovich S, Miller-ter Kuile E, Cheng CH, Enders A. Crop yield, nutrient uptake and leaching, soil water availability, and nitrous oxide emissions with biochar from different feedstocks and produced at different temperatures. Proceedings of the 2nd International Biochar Initiative Conference, Newcastle; 2008.
17. Major J. Biochar: A new soil management tool for farmers and gardeners. Appalachian Sustainable Development. IBI report; 2011.
18. NIMET. Nigerian Meteorological Agency. Lafia Station; 2012.
19. Agbenin JO. Laboratory manual for soil and plant analysis (selected methods and data analysis). Published by the Author. Zaria. 1995;24-44.
20. Ndor E, Iorkua RS. Effect of agricultural land use on carbon sequestration and chemical properties of soil in Lafia, Southern Guinea Savanna Agroecological Zone, Nigeria. Global Journal of Biodiversity Science and Management. 2013;3(1):68-72.
21. Jayeoba OJ, Sangari DU, Alabi RT. Geo-statistical analyses of the spatial variation of soil reaction (pH) in Nasarawa State, North Central Nigeria. International Journal of Science and Advanced Technology (ISSN 2221-8386). 2012;2(5).
22. Chan KY, Van Zwieten L, Meszaros I, Downie A, Joseph S. Agronomic values of greenwaste biochar as a soil amendment. Australian Journal of Soil Research. 2007; 45:629-634.
23. Novak JM, Busscher WJ, Laird DL, Ahmedna M, Watts DW, Niandou MAS. Impact of Biochar amendment on fertility of a Southeastern coastal plain soil. Soil Science. 2009;174:105-112.
24. Oguntunde PG, Abiodun BJ, Ajayi AE, van de Giesen N. Effects of charcoal production on soil physical properties in Ghana. Journal of Plant Nutrition and Soil Science.2008;171(4):591-596.
    DOI: 10.1002/jpln.200625185.
25. Liu X, Zhang A, Ji C, Joseph S, Bian R, Li L, Pan G, Paz-Ferreiro J. Biochar's effect on crop productivity and the dependence on experimental conditions—A meta-analysis of literature data. Plant Soil; 2013.
    DOI: 10.1007/s11104-013-1806-x.

Peer-review history:
The peer review history for this paper can be accessed here:
http://sciencedomain.org/review-history/10609