International Journal of Environment, Agriculture and Biotechnology
Vol-6, Issue-1; Jan-Feb, 2021

Journal Home Page Available: https://ijeab.com/
Journal DOI: 10.22161/ijeab

Effect of biochar and supplementary application of micronutrient on soil and growth of okra in Lafia, Nigeria

Adamu, M. B* and Junaidu, U.G

Department of Agricultural Technology, Federal College of Agricultural Produce Technology, Kano, Nigeria.
*Corresponding Author: belloadamu83@gmail.com

Received: 28 Nov 2020; Received in revised form: 20 Dec 2020; Accepted: 02 Jan 2021; Available online: 09 Jan 2021

Abstract**—** *The study was conducted at the Research farm faculty of Agriculture, Lafia-Shabu campus, Nasarawa State University Keffi. The objectives were to investigate the effect of Biochar and supplementary application of micronutrient on Soil and growth of Okra. Biochar and micronutrient at different rate were considered, Control (zero %), 4tons/ha Biochar, 16 tons /ha Biochar, 4 tons/ha Biochar + 1 litre / ha micronutrient, 16 tons/ha Biochar + ½litre/ha micronutrient, 4tons/ha Biochar + ½litre/ha micronutrient and 16tons/ha biocha+½litre/ha micronutrient. The experiments were laid out and the seven treatments arranged in a randomized complete block design (RCBD) replicated three times. Biochar was drill into the first 5cm of the soil. Micronutrient application was first done two (2) weeks after planting and this was followed weekly. All Soil samples collected were analyzed using standard laboratory soil analysis procedures. Data on growth parameters that were collected include, plant height, leaf area and stem girth. Data was analyzed using analysis of variance (ANOVA). The result showed that, there is no significant (p < 0.05) difference on the vegetative growth parameters of the plant. However, 16tons/ha Biochar increased significantly (p < 0.05) the percentage organic carbon, organic matter, cation exchange capacity, Nitrogen, and pH of the soil. This study demonstrated the potential of Biochar in improving the soil quality in the short term and growth parameters of the plant in the long term. Therefore 16 tons /ha Biochar is recommended.*

Keywords**— *micronutrient, Agriculture, ANOVA, Okra.***

I. INTRODUCTION

Okra, (*Hibiscus esculentus, L.*) belongs to the malvacea family. There are nine to ten species, out of which four are cultivated. There are five species in Africa, there are indigenous and two are alien having been introduced from Asia, one of these species, the West African Okra (A. *Caillei*). Okra plays an important role in the diet by supplying carbohydrate, protein, fat, minerals and vitamins that are usually deficient in the staple food. Okra is basically low in calories and dry matter constituents which when consumed in a meal with basic starchy food makes the food more palatable (Savello *etal* 1982 and Uguru, M. I, 1996)

It is an important vegetable crop grown throughout the tropical and subtropical regions of Asia and Africa (Bisht and Bhat, 2006). Okra is believed to originate probable from south East Asia. It is popular in West Africa, Brazil, Philippian, Thailand, and India. It is distributed also to other Parts of the world by the Portuguese (ECHO, 2003).

In Africa (Nigeria), Okra is cultivated because of it high mucilage content which is used in thickening soup (Purse glove 1968, Wolfe *et al,* 1997). Fresh okra is high in vitamin A, B and C and calcium (NARP, 1993). Significant levels of carbohydrate, potassium, magnesium and other vitamins are also present in okra (Norman, 1992, Adeboye and Oputa 1996).

A mucilaginous preparation from the capsule can be used in plasma replacement or blood volume expander. The mucilage is also used to glace paper and also useful in confectionary (Markose and peter, 1990)

Contiguous use of agricultural land over several years creates on imbalance in the store of nutrients available. Also, increase in cropping density and introduction of high yielding varieties have caused considerable drain of nitrogen and crops showed a positive response to the addition of nitrogen in the soil (Ali *et al*, 2004). Despite the nutritional value of okra, its optimum yields (23t/ha) and quality have not been attended in tropical countries partly because of continued declined in soil fertility.

Serious depletion of soil fertility due to widening gap between nutrient removal and suppliers (Ramesh, 2008).Has affected crop productivity. The use of inorganic fertilizer alone has not been helpful because it promotes and increase degradation of plant nutrients (Sharma and mitral, 1991). The degradation according is brought about by loss of organic Mather which contently results in soil acidity, nutrient imbalance and low crop yields.

Heavy application of chemical inputs such as pesticide, insecticide and chemical fertilizers, greatly deteriorate the environment and also decrease production (Nishio, 1996). Tropical soil after receiving chemical fertilizers tend to be unproductive due to lack of proper amendments of organic malt or. With the growing environmental concerns the sole dependence on chemical input based agriculture is being replaced by integrated multi approach involving conjunctive use of both organic and on organic sources.

Micronutrients are equally important in plant nutrition as macronutrients, the simple occur in plants and soils in much lower concentrations. Plants grown in micronutrients deficient soils exhibit similar reductions in productivity as those grown in macronutrient deficient soils.

The micronutrients elements are Iron (Fe), Manganese (Mn), Copper (Cu), Zinc (Zn), Boron (Bo), Molybdenum (Mo) and Chloride (Cl). They are required by plants in small quantities, in contrast to macronutrients, which constitute relatively larger percentage of plant weight Fe, Mn, Cu, and Zn are Cations, while Mo, Bo and Cl are anions (Agbede, 2009).

According to Remesh, (2008).The use of organic manures particularly Biochar are the only option to improve the soil organic carbon for sustenance of soil quality and future productivity.

Hamer *et al*, (2004) identified that some microorganisms were able to live with Black carbon (BC) as the soil carbon(C) source and that Black carbon in soil may promote the rate of decomposition of labile carbon compound. Biochemist a charcoal substance produced from controlled, incomplete combustion of biomass in an oxygen- free environment. Biochar gives the soil its black colour and improves soil structure, aggregation, water infiltration and retention and nutrient storage capacities (Lehmann *et al*, 2003). One significant feature of Biochar is that it may increase stabilization of organic matter nutrient sources in the soil (Glaser *et al*, 2001) and reduce nutrient leaching losses (Lehmann *et al*, 2003) and hence improve nutrient retention.

Biochar is important as a soil conditioner and also help to spread and transform nutrients (Glaser *et al*, 2002, Lehmann *et al*, 2003). This therefore, makes it possible to modify N, P and S transformation in mineral soils. Besides, it has a high surface area that is highly porous and so has the ability to increase soil water holding capacity, cation exchange capacity (CEC) (Glaser *et al*, 2002, Liang *et al*, 2006).

The use of Biochar to meet the C and N requirements for crops would be inevitable in the years to come for sustainable improved agriculture since it generally retains nutrients in the soil for a long time (Lehmann and Rondon, 2005). It improves the soil physical and biological properties and efficient absorption of ammonium.

All plants require the same basic nutrient but plants differ in the way they respond to nutrient availability and used.

Many researchers have revealed the efficacy of Biochar on increasing growth, yield and essential oil of Okra and other crops in general. Essentially the use of chemical fertilizers alone or sole fertilizers may not be adequate enough to provide food needed to satisfy the needs of the populace. It is therefore expedient to properly combine the necessary soil amendment strategies to produce healthy food from an organic source with no environmental hazards. Soil nutrient and water resources need to be properly managed and conserved (Quansah, 1996).

To achieve this, several rates of micronutrient and Biochar were combined and investigated to ascertain the impact on crop yield and productivity. Therefore, this study was aimed to assess the effectiveness of application of Biochar on Growth and Development of okra, to compare the growth performance of okra on soil amended with Biochar at difference rate of application.

And to evaluate the effect of Biochar and micronutrient on the physiochemical properties of soil.

II. MATERIAL AND METHOD

The study was conducted at the faculty of Agriculture, Nasarawa State University Keffi, Shabu- Lafia Campus, Nasarawa State The location is situated at latitude 08^{o}

33N,longitude 08^O 32E, with mean elevation of 181.53m above sea level . Rainfall usually starts from May – October and the average monthly rainfall figures ranges from 400 -350mm. 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 (NIMET, 2017). The soil is an oxilsol. It is deep porous brownish red and made up of kaolinite clay derived from sandy deposit of sand stone origin. The area is characterized by a sub-humid tropical climate with wet and dry season. The annual rainfall distribution is about 113mm. the mean annual temperature is 27ºC with minimum and maximum temperature of 24.80º C and 33º C respectively

Clemson spineless okra was used for the study, Seed were obtained from technisem co. Ltd, packed in France. Biochar was prepared and crushed in to granule forms at the experimental site. Foliar blend formulated micronutrient was used.

The experiments were laid out in a randomized complete block design (RCBD) comprising seven (7) treatments and (3) three replications. Each experimental plot was 25m^2 (5m x5m). The planting distance adopted was intra row 60 cm and inter row 45cm (60 cm x 45 cm)

Biochar from softwood prune branches were collected from the trees around and were prepared by pyrolysis method as described by Husk *et al*, (2010) using a local/traditional earth-mound oven (clay oven). The materials were cut and sun dried to reach water content of about 20% and then heated in the locally made clay oven. Pyrolysis time was ten days (then it became a wood Biochar).The produced Biochar requiring cooling in an air-tight pit. After the cooling, Biochar were crushed to a coarse powder for laboratory measurements; the Biochar were dry-sieved over 2mm sieved. For experiment, the Biochar were used without further treatment. Biochar characteristics were analyzed by the method as described by Husk *et al;* (2010).

The land was clear, deep ploughed and brought to a fine tilth by repeated harrowing on 10th April, 2018. The plots where prepared and Biochar was applied on 17th April, 2018 and by drilling to the depth of 10cm with the aid of a hoe.

After size reduction Biochar were drill in to the soil to a desirable depth of about 10-15cm and covered with top soil.

The seed were sown on 3th May, 2018. At planting three seeds were placed in each hole created with a hoe at a depth of 5cm and at a spacing of 60cm x 45cm.These were thinned to one plant per stand at 2 weeks after germination (WAG)

In order to keep the soil porous and also free form weeds, hand weeding and hoeing were done as an when necessary. Weeding was done manually with hoe. Weeds were controlled until harvesting was completed at least weed were controlled every two weeks.

To control pest and diseases, the recommended fungicide and insecticide like imi-force was applied at the vegetative stage. The necessary plant protection measures were taken up as per the recommended package. Flea beetle (*Podagrica spp*) the only pest that was noticed was controlled with imi-force.

Three plants from each treatment in each replication were randomly selected and tagged for record taking on growth parameters. Plant height was taking and record using a one meter rule from the base of the stem at soil level to the terminal bud of the plant of a fully opened leaf on the main shoot and the mean height was expressed in cm. Plant height was recorded from 5 weeks, to 10 weeks after planting.Plant leaf area was taken from the leaf of the tag plant and recorded using a meter tape.

Soil sampling were collected, air dried, sieved through a 2mm mesh and prepared for soil routine analysis.

Statistical analysis of the data was carried out using the General linear model of statistical package for social sciences SPSS for Randomized complete block design.

III. RESULT AND DISCUSSIONS

Soil sample was taken and analyzed before application of Biochar. The result explained the physiochemical properties of the soil before the amendment. Table.1 indicated that 16tons/ha biocha+1litre/micronutrient had the highest pH value of 6.71 and 4tons/ha biochar+1litre/ha micronutrient had the highest organic carbon, organic matter and potassium (K) 1.60, 1.85, and 0.64 as well as 4tons/ha Biochar+1/2litre/ha micronutrient with the highest Nitrogen % of 1.21 respectively.4tons/ha Biochar +½litre/ha micronutrient also had the highest CEC and Mg of 5.63 16tons/habiocha+½litre/ha micronutrient, had the highest percentage of sand, Sodium (Na) and Calcium (Ca), 83 %, 0.29 and 3.81

Table.2 showed the effect of wood Biochar on the soil physiochemical properties after harvest. The result revealed that T2 (16tons/ha Biochar) had the highest organic carbon (1.00), organic matter (1.72), sodium (0.87), cat-ion exchange capacity (7.57) and pH value of 6.72 which is favorable for plant growth. While T4 and T6 (16tons/habiocha+½litre/ha micronutrient and 16tons/habiocha+1litre/ha micronutrient) follow with height percentage of organic carbon and organic matter, (0.84, 0.84) (1.44 and 1.44). T_0 (un-amended) had the low pH of 6.26 in salt solution, organic carbon, organic matter, and low CEC (cat-ion Exchange Capacity) of 6.45.

This result is in line with the finding that Biochar addition to soils has a lot of potentialsin Agriculture which include, liming of acid soils, addition of basic cat ions and micronutrients, improving water holding capacity and a gradual release of nutrients to the growing plant (Glaser *et al*, 2002.Laird *et al*, 2010. Soli *et al;* 2010,Vanzwieten *et al*, 2010) leached sandy soils typically have low soil pH values, poor buffering capacities, low cation exchange capacity (CEC), with values ranging from 2-8 cmol kg^{-1} and can have Aluminum(Al)toxicity (Novak *et al;*2009). The addition of Biochar to these highly leached, infertile soils gives an almost immediate increase in the availability of some basic cations (Glaser *et al;* 2002; Liang *et al;* 2006) as well as a significant improvement in crop yields, particularly where nutrient resources are in short supply (Lehmann and Rondon.2006).

Table: 1 Physio-Chemical Properties of the Soil before Biochar Amendment

	TREATMENTS						
Parameters	To	T1	T2	T3	T4	T5	T6
P^H in H_20	7.02	7.14	7.13	7.15	7.12	7.14	7.16
P^H in KCl	6.38	6.56	6.64	6.70	6.40	6.62	6.71
% O.C	0.92	0.94	1.00	1.60	0.98	1.03	1.00
% O.M	1.58	1.65	1.72	1.85	1.42	1.46	1.46
% N	0.41	0.24	0.16	0.35	0.34	1.21	0.45
Avail.P(ppm)	5.03	5.43	6.02	5.43	5.20	5.33	5.38
Na mol/kg	0.28	0.28	0.18	0.22	0.29	0.27	0.26
K mol/kg	0.31	0.56	0.49	0.64	1.44	0.33	1.52
Ca mol/kg	2.73	2.85	3.10	3.34	3.81	2.93	3.26
Mg mol/kg	1.29	1.53	2.25	2.62	1.67	2.70	2.30
E.Ameg/100g	1.00	0.83	0.29	0.61	0.85	0.52	0.25
C.E.C	5.33	5.44	5.45	5.62	5.47	5.63	5.42
Fe (ppm)	2.41	3.52	2.61	1.19	2.91	2.54	2.57
Zn (ppm)	1.26	1.23	1.22	1.23	1.32	1.43	1.24
Cu (ppm)	0.67	0.58	0.57	0.76	0.56	0.73	0.77
Mn (ppm)	1.14	1.05	1.10	0.63	1.20	1.32	1.12
% B.S	80.0	80.0	80.2	80.2	84.4	80.0	80.0
% Sand	78.2	76.5	79.1	79.3	83.0	75.3	76.2
% Silt	11.1	12.1	10.3	11.1	5.6	12.3	10.5
% clay	10.7	11.4	10.6	12.1	10.4	11.4	12.3
T.C	sand	sand	Sand	sand	sand	sand	Sand

O.C =organic carbon, O.M= organic matter, B.S= base saturation, CEC=cat ion exchange capacity

Table: 2 Physio-chemical Properties of the soil after biochar amendments.

	TREATMENTS						
Parameters	To	T1	T2	T3	T4	T5	T6
P^H in H_20	7.11	7.20	7.13	7.20	7.19	7.20	7.20
P^H in KCl	6.26	6.92	6.72	6.94	6.52	6.91	6.98
% O.C	0.70	0.62	1.00	0.80	0.84	70	0.84
% O.M	1.20	1.07	1.72	1.38	1.44	1.20	1.44
% N	0.07	0.07	0.14	0.14	0.28	1.14	0.35
Avail.P(ppm)	3.62	4.10	3.63	4.09	3.98	4.07	4.08
Na mol/kg	0.86	0.67	0.87	0.61	0.58	0.72	0.69
K mol/kg	0.13	0.10	0.18	0.23	0.34	0.28	1.30
Ca mol/kg	3.01	3.24	3.16	3.52	3.18	3.36	3.26
Mg mol/kg	1.34	1.56	1.26	1.70	1.63	1.58	1.46
E.Ameg/100g	1.17	2.00	1.00	0.67	0.83	0.67	0.33
C.E.C	6.45	6.51	7.57	6.73	6.53	6.61	6.04
Fe (ppm)	1.13	1.14	1.01	0.97	0.89	1.04	1.01
Zn (ppm)	3.10	3.03	2.98	2.87	3.11	2.90	2.87
Cu (ppm)	0.06	0.09	0.10	0.08	0.11	0.06	0.05
Mn (ppm)	0.03	0.06	0.08	0.10	0.04	0.06	0.07
% B.S	82.0	74.0	84.0	90.0	78.0	90.0	81.0
% Sand	90.6	90.5	90.0	90.6	90.0	90.0	90.2
% Silt	1.4	1.5	1.4	1.4	1.5	1.4	1.5
% clay	8.0	9.0	8.6	8.0	9.0	8.6	9.0
T.C	Sand	sand	Sand	sand	sand	Sand	Sand

O.C =organic carbon, O.M= organic matter, B.S= base saturation, CEC=cat ion exchange capacity

Effect of Wood Biochar and Supplementary Application of Micronutrient on plant Height (Okra)

After Biochar and Micronutrient application on the research area (soil) there was no significant ($p < 0.05$) increase of the plant height from the treatments at 5WAP,6WAP,7WAP,8WAP,9WAP and 10WAP respectively. Table: 3 However, the highest plant height (25.88cm) was obtained from the application of 0kg Biochar and 0 liter Micronutrient (control) at 10WAP. While the lowest plant height (22.58cm) was obtained from the application of 16tons/ha Biochar and 1litre/ha Micronutrient at 10WAP.this result is agree with the finding of Glaser *et al*,2002that, Biochar work better in the second and third year of application than it does in the first year of application

Effect of wood Biochar and supplementary of application of micronutrient on plant leaf area of okra

Table: 4 presents the effects wood Biochar and supplementary application of micronutrient on leaf area of okra. The result of the study revealed that there is no significant different in leaf areas of the treatment from 5WAP, 6WAP, 7WAP, 8WAP, 9WAP, and 10WAP.

The plant with the highest leaf area (29.96 cm and 29.02 cm was observed from the application of 16tons/ha Biochar+1/2litre/ha micronutrient and 0kg/ha Biochar+0litre/ha micronutrient then 16tons/ha Biochar had the lowest leaf area of 14.78cm at 5WAP. While at 8WAP 16tons/ha Biochar had the highest leaf area of 88.13cm then 4tons/ha Biochar+1/2Litre/ha micronutrient had the lowest leaf area of 1.23cm respectively.

ISSN: 2456-1878
https://dx.doi.org/10.22161/ijeab.61.1

Table 3. Effect of wood Biochar and supplementary application of micronutrient on plant height of okra

TREATMENT	5WAP	6WAP	7WAP	8WAP	9WAP	10WAP
Control	7.03	8.67	11.67	15.60	22.43	25.88
4tons/ha Biochar	6.29	8.24	10.55	11.88	19.88	21.60
16tons/ha Biochar	5.18	5.78	8.11	10.91	17.13	18.42
4tons/ha Biochar +1 litre/ha micronutrient	6.24	7.89	10.06	12.35	19.58	21.98
16tons/ha Biochar + $^1/_2$ litre/ha micronutrient	6.69	8.83	11.61	15.25	22.27	25.34
4tons/ha Biochar + $^1/_2$ litre/ha micronutrient	5.67	7.07	9.782	11.92	18.56	20.20
16tons/ha Biochar +1 litre/ha micronutrient	5.93	7.50	9.92	12.38	19.53	22.58
Means	6.16	7.72	10.25	12.03	19.93	22.27
Significant	0.564^{NS}	0.440^{NS}	0.734^{NS}	0.674^{NS}	0.953^{NS}	0.846^{NS}

WAP= week after planting

NS= not significant

Table: 4 Effect of wood Biochar and supplementary application of micronutrient on plant leaf area of okra (cm^2)

TREATMENT	5WAP	6WAP	7WAP	8WAP	9WAP	10WAP
Control	29.96	45.45	49.73	1.73	1.96	2.32
4tons/ha Biochar	26.12	34.84	43.70	1.32	1.56	1.91
16tons/ha Biochar	14.78	23.45	39.90	88.13	1.36	1.58
4tons/ha Biochar +1 litre/ha micronutrient	19.72	29.52	49.62	1.33	1.48	1.95
16tons/ha Biochar + $^1/_2$ litre/ha micronutrient	29.02	54.55	63.63	1.52	1.64	2.13
4tons/ha Biochar + $^1/_2$ litre/ha micronutrient	21.83	28.96	45.57	1.23	1.65	5.79
16tons/ha Biochar +1 litre/ha micronutrient	15.04	21.69	47.05	1.28	1.99	2.44
Means	22.72	34.69	48.53	1.33	1.65	2.59
Significant	0.886^{NS}	0.712^{NS}	0.979^{NS}	0.885^{NS}	0.917^{NS}	0.653^{NS}

The study shows that Biochar application increased soil pH on acidic soil and reduce leaching of organic carbon, organic matter, Nitrogen, Sodium, Potassium, Calcium and cation exchange capacity (CEC). Compared to un-amended treatment the study revealed not significant ($p < 0.05$) different on growth parameter (plant height, leaf area and yield of okra. This is in conformity with the study by (Lehmann, 2007) which said that fresh Biochar shows moderately low plant performance and cation retention properties relative to age Biochar.

Before sowing, the result of the soil analysis in table:1 revealed that the percentage of nitrogen, phosphorus, calcium and available K decreases at first among the treatments but there after increase significantly ($p < 0.05$) after harvesting especially on treatments which received the high rate of biochar.16tons/ha+½litre/ha micronutrient and 16 tons/ha+ 1litre/ha micronutrient had the highest organic carbon, organic matter and favorable pH for plant growth as shown in table: 2 compared to un-amended treatment (control) which has low organic carbon (0.70) organic matter (1.20), and CEC (6.45).After sowing to (un-amended soil) had lower pH (6.26) which is slightly acidic in alkaline solution compared with the Biochar applied treatment of pH (6.52, 6.72,) which is nearly neutral. Average pH range for plant growth (Agbede, 2009). The application of Biochar to soil changes their pH to a near neutral especially in an acidic soil. The result also shown significant ($p < 0.05$) changes in soil cation exchange capacity and pH of the soil in question presented in Table :2 this agreed with (Lehmann *et al*, 2003) that soil cation exchange capacity (CEC) has to increase with the addition of Biochar. Biochar can be used as soil amendment to improve soil quality (Blackwell *et al*, 2009).

IV. CONCLUSION

Application of Biochar to soil has increased significantly ($p < 0.05$)the soil properties. This study revealed that Biochar addiction to the soil increased the soil N, P, K, Ca, Mg and soil pH it also played a major role in lowering E.C of the soil to enhance better nutrient availability as well as serving as a limiting agent which increased the pH from 6.26 to 6.72 which is ideal for okra production. 16tons/ha Biochar result on the increase in organic carbon, organic matter, cation Exchange capacity and favorable soil pH for Okra growth. It is therefore recommended that Biochar at 16tons/ha should be used or adopted to give better results for farmers. This recommendation corroborates with the fact that inorganic fertilizers are becoming too expensive to procure by small-scale farmers and also Biochar can stay for a long time in the soil.

REFERENCES

[1] Adeboye, O.C., and oputa, C., O. (1996) *Effect of Different levels of manures on seed yield of Okra.* Proceeding 26th Annual conference of soil science society of Nigeria 21st - 25th November, 1999, Benin, Nigeria.

[2] Agbede, O.O (2009) *Understanding Soil and Plant Nutrition* Nigeria by Petra Digital press Pp. 203- 206

[3] *rice production in northern Laos*field Crops Research 111: 81-84.

[4] Ali, H. S., A., and Yousaf, M. (2004). Quantitative and Qualitative traits of sunflower as influenced by planting dates, Nitrogen application Institute J. Agric Bio 1-6; 410

[5] Bisht, I., S., and Bhat. V (2006). *Genetic Resources Chromosome Engineering and crop Improvement Okra (Abelmoschus spp*), Chapter 5pp (149-185)

[6] Blackwell, P., Riethmuller, G and Collins, M. (2009*).Biochar Application to soil* (Chapter 12) in: Lehman, J., Joseph, S., (Eds), *Biochar Environment management science and Technology.*Earthscan, Londin, U.K, P, 207.

[7] ECHO, (2003) Plant information sheen NFT Meyers. U.S.A. httpwww.echonet.org

[8] Glaser. B, Lehmann. J, and Zech, W. (2002) Ameliorating physical and Chemical properties of highly weathered soils in the tropics with Charcoal-a review: Biology and fertility of Soils 35:219-230.

[9] Glaser Haumaier. L, Guggenberger. G. and Zech, W. (2001) 'The Terra preta" phenomenon: A model for sustainable agriculture in the humid tropics', Naturwissenschaften, vol 88, pp37-41

[10] Husk B. Major, J. (2010). Commercial scale agriculture biochar field trial in Quebec, Canada, over two years: *Effects of biochar on soil fertility, biology, crop productivity and quality.* Disponibleengne http://www.blueleaf.ca/mainen/files/BlueLeaf%20Biochar %20Field%20Tria%2008-09%20Report- 2%20EN.pdf

[11] Hamer, U., B. marschner, S. Brodowski, and Amelung, W. (2004) *Interactive priming of black carbon and glucose minerazation,* Organic Geochemistry 35: 823-830.

[12] Lehmann, J. (2007): A Handful of Carbon. Nature 447: 143-144pp

[13] Laird D., Fleming P ,Wang B, Horton, R and Karien, D. (2010).*Biochar impact on nutrient leaching from a mid-western agricultural soils* Geodderma 185, 436-442.

[14] Lehmann, J. (2003). Comment on "Fire-Derived Charcoal Causes of Forest Humus". Science 321:1295c

[15] Lehmann, J. (2007), Bio-energy in the black Frontiers in Ecology and the Environment, Vol. 5, pp. 381-387.

[16] Lehmann and Rondon, M. (2006 Bio-char Sequestration in terrestrial Ecosystems –A Review. Mitigation and Adaptation Strategies for Global Change.11:395-419.

[17] Lehmann J, Kern. D. C, Glaser, B. and Wood W.I (2003).Amazonian Dank Earths origin properties. Management, Kluwer Academic Publishers, the Netherlands.

[18] Lehmann, J., and Rondon M., (2005).*Biochar soil management on highly- weathered soils in the humid tropics* in N: Uphoff (ed.), Biological Approaches to sustainable soil systems. Boca Raton CRC press in Press

[19] Liang, B., Lehmann, J., Solomon, D., Kinyangi, J., Grossman, J., O'Neil, B., Skjemstad, J., O., thies, J., Luizao, F.J., Peterson, J., and Neves, E. G. (2006). *Black carbon increase cation exchange capacity in soils,* soil science society American Journal, Vol. 70, pp. 1719- 1730.

[20] Markose, B., L., and peter, K.V. (1990).Okra. Review of research on vegetable and Tuber crops. Technical Bulletin 16 Kerala Agricultural University Press Mannuthy Kerala, 109pp.

[21] NARP, (1993) National Agric project Horticultural Crops Vol.3, July 1993 NARP, CSIR Accra.

[22] Nishio, M (1996). Microbial Fertilizes in Japan FFTC-Extension Bulletins 1-12 National institute of Agro-Environment sciences, Ibaraki Japan.

[23] Norman, J.C. (1992) Tropical Vegetable Corps Authur, H., Stockwell Ltd, Elms,C., Francanbe Devon, 252pp.

[24] Novak, J. M., Busschar, W.J., Laird D.L., Ahmedna, M., Watts D.W., Niandou, M.A. S., (2009) Impact of Boichar Amendment on fertility of a South Eastern Coastal plain Soil, Soil Science 174,105-112.

[25] Purse glove J.W., (1968). Tropical crops dioyledons Vol. land 2 Combined Longman, London pp 719.

[26] Quansah, C. (1996). *Soil Water and nutrient management needs forsustainable crops production*. Proceedings of DSE international seminar on tools for Analysis and Evaluation for sustainable land use in Rural Development pp38-46 DSE Zscortan, Germany

[27] Remesh, P., (2008), Organic farming research in M.P. organic farming in rain fed agriculture: Central Institute from dry Land agriculture, Hyderabad, pp.-13- 17.

[28] Savello, P. A., F. W. Martin and J. M. Hull, (1982) *Nutrition Composition of okra seed meal* .J .Agr. Food Chem., 28: 1163-1166.

[29] Sharma A.R., and., Mittral, B.N. (1991) *Effect of different rates of application of organic* on C Journal of Agricultural science (Cambridge) 117: 318 DOI: 101017/S002185960007046

[30] Sohi S. P., Krull E., Lopez-Capel E., and Bol. R., (2010) A review of biochar and its use and function in Soil Advances in Agronomy IOS, 47– 82.

[31] Uguru M.I. (1996) *Crop Production Tools, Techniques and Practice* Fulladu Publishing Company B1 Umeano Estate College Road Nsukka Pp. 152-153.

[32] Van Zwieten, L, Kimber, S, Downie, A. Morris, S, Petty, S, Rust J & Chan, KY (2010), 'AGlasshouse study on the interaction of low mineral ash biochar with nitrogen in a sandy Soil', Australian Journal of soil Research 48(6-7): 569-76

[33] Van Zwieten L, Kimber S, Morris S, Chan K. Y., Downie A., Rust J., Joseph S., and Cowie A., (2010)*Effects of biocher from slow pyrolysis of papermill waste on agronomic performance and soil fertility plant and soil*. 327, 235-246.

[34] Wolfe M. L., Martin, F. C., Otchere, G., (1997), *Studies on the mucilages extracted from okra fruits (hibiscus esculentus L.) and baobab leaves* (*Adansoniadigitata L*.) J. Sci. food Agric 28: 519- 529.