RESPONSE OF OKRA (*Abelmoschus esculentus* L.Moench) TO BIOCHAR DERIVED FROM COCOA POD HUSK AND NPK

BY

ONWU, ROSANA CHINAKA
SSC/12/0482

A THESIS SUBMITTED TO
THE FACULTY OF AGRICULTURE, DEPARTMENT OF SOIL SCIENCE AND LAND RESOURCES MANAGEMENT, FEDERAL UNIVERSITY OYE-EKITI
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF BACHELOR OF AGRICULTURE (B.Agric.) IN SOIL SCIENCE
FEDERAL UNIVERSITY OYE-EKITI NIGERIA

NOVEMBER, 2017

CERTIFICATION

This is to certify that this research was carried out by ONWU ROSANA CHINAKA, in the Department of Soil Science and Land Resources Management with Matric Number SLM/12/0482. Federal University Oye-Ekiti, Ekiti State, Nigeria.

....

Dr. Anthony K. Oluleye.

Supervisor

Date: 6-12-2017

..................................15/12/17

Prof. O.S. Shittu

Head of Department

Date: 18/12/17

ABSTRACT

The need to improve soil fertility and enhance crop production has led to a renewed interest in the use of cocoa pod husk (CPH) in form of biochar, an organic fertilizer, relative to mineral fertilizer as soil amendment. The deleterious effect of inorganic fertilizer, on the environment, has been enumerated and the global effect of CPH.

Field experiment on okra (*Abelmoschus esculentus*) fertilized with Biochar, derived from cocoa pod husks (CPH), was conducted at the Cocoa Research Institute of Nigeria (CRIN), Ibadan, between June and November 2016, to evaluate the effectiveness of the organic fertilizer relative to the inorganic NPK fertilizer. The effect of the amendment on the soil chemical property was also evaluated .The experiment was laid out in a Randomized Complete Block Design with three replications. NPK 20-10-10 fertilizer, was applied at 60 and 30kg/ha with mixture of biochar at 5kgN/ha and 2.5kgN/ha respectively.

The field data include plant growth parameters which were taken at two weeks after planting, on weekly basis up to eight weeks and fruit yield from eight to sixteen weeks. Data were analyzed using analysis of variance (ANOVA) and economic analysis. Results from plant height, stem girth, number of leaves, biomass accumulation, nutrient uptake and yield showed that the growth and yield of okra were significantly (P< 00.5) different with NPK 60kg/ha + Biochar 5kgN/ha , soil amendment compared to the inorganic fertilizer treatment alone. The improvement in soil pH was 0.69 <1, for this treatment, which indicated that the effect of the fertilizer, is beneficial to plant nutrition.

Economic analysis showed the marginal rate of return was highest for this treatment, compared to other treatments.

Keywords: Okra (*Abelmoschus esculentus*), NPK fertilizer, Biochar, Coca pod husk, economic analysis.

Word count: 289

ACKNOWLEDGEMENT

My eternal gratitude goes first and foremost, to the Almighty God the creator of heaven and earth for sparing my life during the course of the study and made it possible to successfully finish this programme.

I am most grateful to my supervisor, Dr. Anthony K. Oluleye, my head of department Prof. O.S Shittu, also to be mentioned is Dr.M.O Ogunlade, of the Cocoa Research Institute of Nigeria who provided leadership during the course of the field work.

I paid tribute to my late Father, Onwu Matthew and prayed for prolonged life for my Mother, Mrs Catherine Onwu, I really appreciate, may you live long to reap the fruit of her labour in good health in Jesus name .(Amen).

My heartfelt gratitude goes also to my siblings: Onwu Gloria, Onwu Moses, Onwu Aloy, Onwu Augustine and Onwu Grace for their love, care assistance and support. I love you so much. God bless you all.

I am grateful to all staff in the faculty of Agriculture and those in the Department of Soil Science and Land Resources Management and all others involved in my academic career.

My sincere thanks goes to my Priests; Rev. Fr. Francis Alade, Rev.Fr. (Prof) James. A .Olaogun, Rev. Fr. Anthony Ogwu, Rev.Fr. Nonso and Mr. Odumah Anthanasius that have contributed to my academic pursuit in one way or the other. In the same vein, my appreciation goes to the Roman Catholic Church, as a whole and all Organizations, including the Nigeria Federation of Catholic Student FUOYE Chapter, Catholic Youth Organization of Nigeria, for the grace of God, I enjoyed throughout my stay in the School.

I am highly indebted to my colleagues in the department of soil science and land Resource Management and very good friends, Ademola Isaac, Awopetu Oluwafemi John, Ewoh Emmanuel Chiyeaka, Victor –Sunday Samuel, and Ezekiel Ahunanya in Federal university Oye

–Ekiti (FUOYE), to mention but a few, please forgive me, you are always in my heart. I thank to you all.

Finally, my gratitude goes to the Almighty God, who made everything possible

DEDICATION

This work is dedicated to the glory of God Almighty, the Author and the Finisher of our faith, without Him nothing would have been done, His mercy endures forever.

Table of Contents

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

APPENDICES **page**

LIST OF PLATES

CHAPTER 1

INTRODUCTION

Okra (*Abelmoschus esculentus* L. (Moench), is an economically important vegetable crop grown in tropical and sub-tropical parts of the world, it was cultivated by the ancient Egyptians and originated from Ethiopia by the 12th century B. C.. This crop is suitable for cultivation as a garden crop as well as on large commercial farms; it is grown commercially in some countries such as India, Turkey, Iran, Ghana, and the Southern United States (Yadev and Dhanker, 2002). India ranks first in the world with 3.5 million tonnes (70% of the total world production) of Okra produced from over 0.35 million hectares of land (FAO, 2008). Data from Food and Agricultural organization statistics in 2005, on Okra output in Nigeria between 1995-2004, showed that quantity of Okra output in Nigeria fluctuates every year due to lack of attention paid to the production and marketing of the products, more also there was reduced interest by the farmers to continue production as a result of low returns from its production. Allied to this losses incurred due to inefficient pricing and marketing system as well as short shelf life of Okra.

Okra is an important vegetable which contributes to the diet of many. The nutritional value of Okra is worth 33kcal,7.6g carbohydrate, 2.4g protein, 31mg vitamin C, 0.32 vitamin A and 0.17g vitaminB2 (Eke *et al.*,2008). Okra is mainly cultivated for the pods/fruits which are harvested in the immature stage only to be used freshly (or in dried and ground state) for cooking soup or stew.(Bemire and Oke,2003), okra in annual crop grown mainly as fruits and leafy vegetable (Gibbon and Pain, 1984).

Okra is cultivated under rain fed and in irrigated areas and on wide range of soils but loamy soils supports higher yields (Akoma,1985; Adenekan *et. al.,* 2008).Nigeria average yield of okra per hectare was reported as low as 2.6t/ha (FA0 2005) while experimental yield ranged from 3.5 to 8.8t/ha (Akoroda, 1982; Adejonwo *et,al.,* 1989).This was due to inappropriate use of fertilizer (Faraq and Danrany 1994) .

There are need to explore the use of organic fertilizer which are environmentally friendly (Schnug *et al.,* 1996). Unlike inorganic fertilizer which posed hazard to the environment. Biochar is an organic fertilizer, which contains high amounts of carbon and synthesized by process of pyrolysis (Pessenda *et al.*, 2001) using raw materials, such as poultry litter (Koutcheiko *et al.*, 2007), biomass (Kwapinski *et. al.*, 2010), Biochar has high residual effect on the soil, thereby making its nutrient available for years. (Schmidt *et. al.*, 2002). Biochar has beneficial effects on the soil, (Hammes and Schmidt, 2009; Lehmann *et al.*, 2011). It increases the soil organic matter (SOM) (Verheijen *et. al.*, 2009). Besides this, it improves soil pH, which increases the cation exchange capacity level and is beneficial for the growth of the plants (Verheijen *et al.*,2009).

Biochar is a cheap source of fertilizer compared to others. Thus, biochar can be more helpful to plants as compared to inorganic fertilizers. Organic fertilizer improve soil fertility by activating soil microbial biomass (Ayuso et al., 1996). Application of organic fertilizer sustains cropping system through better nutrient recycling (El-Shakweer et al., 1998).

Continuous crop production has impoverished the soil. Large quantities of cocoa pod husk are generated as wastes in various cocoa farms, which could be harnessed. This resultant greenhouse gasses emitted contributes to global warming, through its disposal method in landfill, mulching, composting and burning. However, these organic materials could be used to produce biochar through pyrolysis thereby sequestering carbon, reduced global warming, as well as serve as soil amendment (Ogunlade *et, al.*2011). Hence the need to improve soil fertility and enhance crop production, has led to a renewed interest, in the use of cocoa pod husk (CPH), in form of biochar relative to mineral fertilizers, as soil amendments.

The general objective of the experiment was:

- to evaluate the response of okra to biochar derived from cocoa pod husk.

And the specific objectives were to:

- evaluate CPH biochar as organic input in crop production;
- determine response of okra to different combinations of biochar;
- evaluate residual effects of biochar on the soil; and
- economic analysis of use biochar and NPK fertilizer.

CHAPTER 2

LITERATURE REVIEW

2.0 Okra (Abelmoschus esculentus L. Moench)

Okra (*Abelmoschus esculentus* L. Moench) is an important vegetable which contributes to the diet of many. Okra is mainly grown for the pods/fruits which are harvested in the immature stage only to be used freshly (or in dried and ground state) for cooking soup or stew. Okra *(Abelmoschus esculentus)* is an annual crop grown mainly as fruits and leafy vegetable in both green and dried state in the tropics (Gibbon and Pain, 1984). The crop is used as a soup thickener which may also be served with rice and other food types and the fresh fruit has been reported to be a good source of vitamins, minerals and plant protein (Eke *et al.* 2008). Okra plant contains 20% edible oil and fiber (Akoma,1985, Adenekan *et.al.*,2008),

2.1 Okra production in Nigeria

Okra is a tropical vegetable of national importance grown in Nigeria, it serve as source employment, food, and source of raw material for confectionery industry. It is one of the most important food and agricultural commodities. It's production occupies1-2million hectares, and in 2004, 730,000 metric tons of Okra was produced in Nigeria. (Grubben 1977, FOS, 1991).

It is usually produced on small holding in mixtures with other staple food crops such as, cassava, cowpea, peanut etc. Vegetable crops (Ayodele1983, Monroe and Asiegbu1996, Olasantan 2001).

2.2 Climate and soil requirements

Okra requires a long, warm and humid growing period. It can be successfully grown in hot humid areas, but. It is sensitive to frost and extremely low temperatures. For normal growth it thrives well in a, a temperature between 24°C and 28°C is preferred. At 24°C the first flower bud may appear in the third leaf axil while at 28°C it may appear in sixth leaf axil. This higher position is not necessarily accompanied with a delay in time because at higher temperatures the plants grow faster and the higher position is reached earlier. For faster plant growth still higher temperature helps though it delays the fruiting. But at higher temperatures beyond 40°–42°C, flowers may desiccate and drop, causing yield losses. For seed germination, optimum soil moisture and a temperature between 25°C and 35°C is needed with fastest germination observed at 35°C. Beyond this range the germination will be delayed and weak seeds may not even germinate.

Relatively light, well-drained, rich soils are ideal. As such, loose, friable, well manured loamy soils are desirable. A pH of 6.0–6.8 is ideally-suited. All soils need to be pulverized, moistened and enriched with organic matter before sowing.

2.3 Economic Importance of Okra

Fruits are cooked in a various ways. The roots and stems are used for clearing the cane juice from which guror brown sugar is prepared. The ripe seeds are used as substitute for coffee in Turkey. It is much useful against genito-urinary disorders and chronic dysentery. Galactomanan in the seeds is used for gum preparation which has several medicinal values.

Okra provides numerous health benefits. Known as a high-antioxidant food, okra support improve cardiovascular and coronary heart disease, type 2 diabetes, digestive disease, and even cancers. Okra is also abundant in several vitamins and minerals, including thiamin, vitamin B6, folic acid, riboflavin/vitamin B2, zinc and dietary fiber.

There are seven okra nutrition benefits: Source of Calcium, Improves Heart Health, Improves eyesight, good source of protein, helps lower Cholesterol, Helps, stabilize blood sugar, good for digestion

2.4 History and development of biochar

Biochar is the solid residue obtained after the pyrolysis of organic material under zero or limited oxygen level. Pyrolysis is a process of combusting organic materials (biomass) under limited oxygen level (Fagbenro et, al., 2015). This process alters the molecular configuration of the organic material, making biochar more stable form than the material from which it was derived, thus reducing its rate of decomposition (Krishnakumar *et al.*, 2013).

The term biochar refers to the carbon - rich solid material resulting from the heating of biomass in a closed container with little or no oxygen (Lehmann and Joseph, 2009a). When added to soil, biochar has been reported to increase the available nutrients, prevent nutrient leaching, greatly reduce requirement for mineral fertilizers, and increase soil Cation exchange capacity. It has also been found to stimulate activity of agriculturally important soil microorganisms, reduce emission of greenhouse gases (GHGs) such as CO2, CH4, N_2O from soil, and reclaim polluted soils (Lehmann and Joseph, 2007).

Biochar has also been reported to last several years in the soil because of its aromatic structure which makes it resistant to microbial degradation (Lehmann and Josepsh , 2009), capable of eliminating the centuries-old slash - and burn form of agriculture so common in the tropics.

Biochar is a name for charcoal when is used for a particular purpose, especially as a soil amendment. Like most charcoal, biochar is created by pyrolysis of biomass. Biochar is under investigation as an approach to carbon sequestration to produce negative carbon sequestration, independently. Biochar can increase soil fertility of acidic soil (low pH soil), increase agricultural productivity ,and provide protection against some foliar and soil-borne disease is a stable solid , rich in carbon and can endure in soil thousands of years

2.5 Effect of biochar on crop production

Biochar can be designed with specific qualities to target distinct properties of soil. It creates a higher crop uptake of nutrient and provides greater soil availability of nutrient. Biochar improves soil tilth, productivity and as well as soil fertility therefore less inorganic fertilizer is needed because it absorb and slowly release nutrient to plant. The soil that is been enhanced by biochar can indefinitely sustain agricultural production, as non- amended soil quickly become depleted of nutrients, making farmers to abandon their field (Stembeiss and Antonietti, 2009).

Biochar is a desirable material in many locations due to its ability to attract and retain water. This is because of its porous structure and high surface area, so nutrient phosphorus and agrochemicals are retained for plant benefit. Plants are therefore healthier and fertilizer leaches less into surface or ground water. Biochar enhances soil by converting agricultural waste into a powerful soil enhancer that holds carbon and make soil more fertile and this was earlier reported by Lehmann (2007), that biochar can increase the soil carbon content permanently.

Biochar increase soil CEC resulting in improved soil fertility. Cheng *et. al.*, (2006) ascertained that, there is a rapid initial surface oxidation of fresh biochar that seems to be caused by a biotic processes rather than biotic processes. The initial oxidation leads to mineralization of biochar and create negatively charged surface areas increasing the cation exchange capacity and the cation retention which should implies soil fertility improvement (Cheng *et. al.*, 2006, Liang *et, al.*, 2006; Glaser *et.al.*, 2002).

Biochar reduces soil nutrient leaching and this was earlier reported by(Lehmann et;al. 2009) , except for the purpose of increasing productivity in agriculture application of biochar may also result in reduced nutrient leaching restoration of degraded land and sequestration of carbon from the atmosphere.

Biochar applied together with mineral fertilizer has shown yield improvements that probably as a result of increased surface area and cation exchange capacity (CEC) due to the biochar application. The sorptive capacity of biochar is controlled by carbonised and non-carbonised fractions as well as the surface and bulk properties (lehmann, *et, al.2009*). Alexander. (1993), reported that polymer or resin coated fertilizer can be tailored in a way that the period extend up to 12 month or more.

It is important to understand that biochar is not an actual fertilizer although at this time. Biochar amendment tool which play the role or enhance fertilizer properties, depending on the feedstock and pyrolysis conditions. It can provide more nutrients.

2.6 Importance of Inorganic fertilizer in crop production

Inorganic fertilizers are the fertilizer that contains one or several plant nutrient, which are mostly present in a concentrated, easily soluble form Agboola and Odeyemi(1993). Hence, they are used to ensure ready presence of a food in the soil. Mineral fertilizer can be straight fertilizer such as Murate of potash (MOP), Single super phosphate (SSP) or compound fertilizer like N.P.K 15:15:15.

Agboola and Odeyemi, (1993) noted that the use if inorganic fertilizer alone has been ineffective in the maintenance of soil fertility in Nigeria. This could be attributed to low cation exchange capacity (CEC) of the most of the soil which implies low nutrient holding potentials. Because of the relative low manufacturing cost and low transportation cost per unit of nitrogen, there has been a wide spread move to use urea as the major form of nitrogen produced and use. Thus nitrogen fertilizer can be lost by leaching erosion, run- off or by gaseous emission. This most common and also the best at preventing Nitrate leaching is to use the mineral fertilizer in combination with organic materials (People *et, al.*, 1995).

Mineral fertilizer is more susceptible to leaching and other losses of nutrients when applied e.g soil acidification, climate change impacts etc (Murwira and kirchman 1993). Inorganic fertilizers that leach the soil below the root systems are not only wasted since they are not accessible to plant but can also pollute water bodies. Biochar when added to soil has been reported to increase available nutrients and prevent their leaching stimulate activity of agriculturally important soil micro organisms and enhances the mineral fertilizer use efficiencies (Lehmann 2007).Therefore the main objective of this study is to determine the response of okra to the application of biochar derived from cocoa pod husk in combination with NPK mineral fertilizer and compare same with application of NPK fertilizer alone.

2.7 Organo -mineral fertilizer use in Nigeria

The increase fertilizer demand in Nigeria, whose requirement was put at 1.2 million tonnes in 1985-1987 period continued while the country's total fertilizer supply increased from 750,000 tonnes in 1988 to 1.65 million tonnes in 1994, this was followed by drastic reduction in supply to 835,000 tonnes in 1995 which continued the trend since then 2(Obigbesan, 1999). The use of organically sourced material is expected to come in as a complement for mineral fertilizer which is becoming expensive and difficult to get for the average Nigeria and indeed most third world farmers, (Obatolu,1995) consequently, the use of mineral fertilizer is at the lowest ebb among Nigerian farmers.

Organo –mineral fertilizer has been able to combat some of these problems, has liming effect of soils, provide required nutrient as well as enhancing the soil organic matter content, water holding capacity and generally improve physico-chemical properties of the soil.

2:8 Use of combination of Biochar with NPK

The combination between biochar and inorganic fertilizers. (Lombin. *et. al.* 1991) reported that complement use of biochar and mineral fertilizer has been proved to be a sound fertilizer management strategy in many countries of the world . Kang and Balasubramanian (1990) affirmed that high and sustained crop yield can be obtained through the combination of NPK fertilizer and Biochar.

Murwira and kirchman (1993) observed that nutrient use efficiency; crop nutrient uptake might be increased through the combination of biochar and mineral fertilizers. Combination of fertilizers protect the soil from nutrient leaching, foliar and soil borne disease and reduce soil acidity.

CHAPTER 3

MATERIALS AND METHODS

3.0 General feature of the study area

3.1 Geographical location

In Ibadan, Cocoa Research Institute, where the field experiment was conducted, has these geographical coordinates (Latitude 7° 13' 15.114'' N and longitude 3° 52' 1.698'' E. 360m above the sea level). The climatic characteristics, the rainy season generally start by March becoming fully established in May and ending in October. Although, there are yearly variation in the distribution and length of the rainy season, the average of several years' data indicated bimodal rainfall pattern, with peaks in June and September. Temperature varies between a maximum of 36^0C and minimum of 21^0C, the low extremes coinciding with the rains and the cold –dry harmattan winds.

3.2 Field experiment

The field experiment was conducted at Cocoa Research Institute, Ibadan, between July and October, 2016. NPK 20:10:10 fertilizer was applied solely at the rate of 60kg ha^{-1} and 30kg ha^{-1} and Biochar at 5 kgN ha^{-1} and 2.5kgNha^{-1} and in mixtures respectively A treatment without added fertilizer was included as control . The treatment were arranged in Randomized Complete Block Design. Fig.1

Three seeds of Okra (47-4 variety) sourced from NIHORT were planted per hole, later thinned to one plant per hole at a spacing of 50cm by 30cm; 50cm being inter row spacing and intra row spacing of 30cm,with a population of 25 stands per plot. The plants were grown for 16weeks and data collection such as , stem girth, leaf number, plant height, were taken on weekly bases up to 2 to 8 weeks while fruit number, fresh fruit weight and biomass yield were collected at physiological maturity from 8 to16 weeks after planting .

At each period, plant samples were also harvested. The plant samples were cleaned with a clean weight moist cloth before taking the fresh weight and then dried in an oven at 70°C to constant weight. After weighing, the dried samples were ground using Cyclotec 1093 sample mill .The plant samples were then analyzed for N,P and K contents after digestion by a dry ash procedure of Chapman and Brat(1961). The uptake was determined by multiplying respective contents with the dry matter yield.

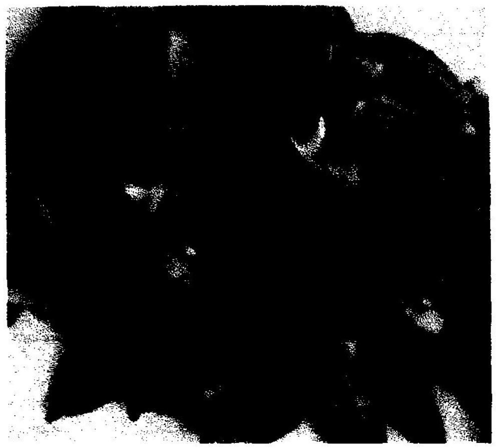


Plate 1: Okra 47-4 variety

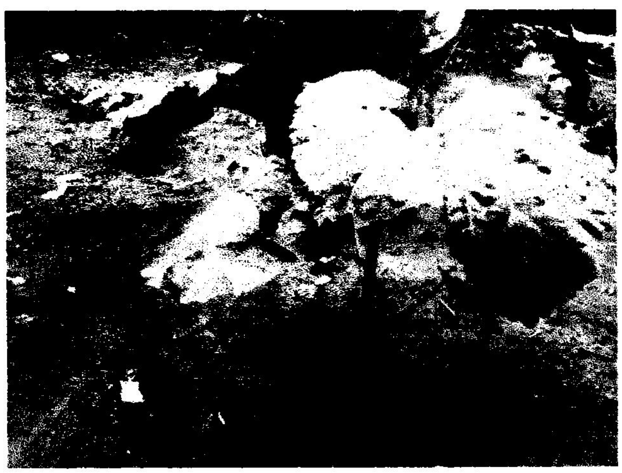


Plate 2: Okra plant on the experimental field

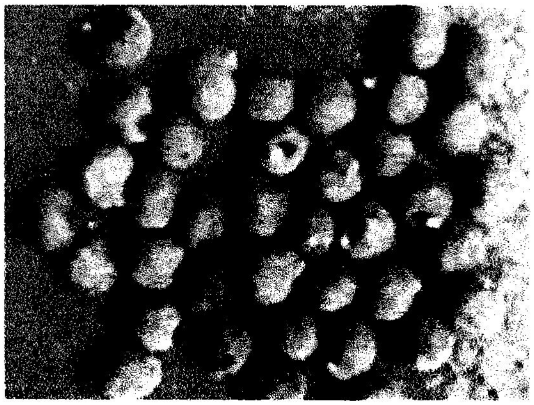
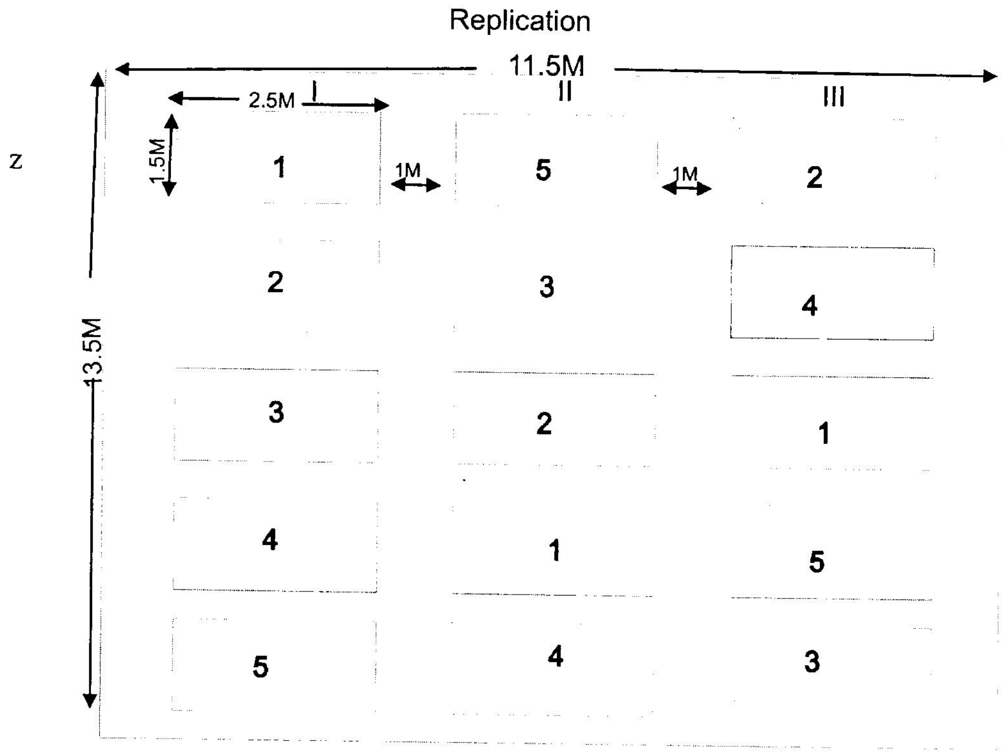


Plate 3: Okra seeds sourced from NIHORT

All data were subjected to analysis of variance (ANOVA) using the general linear model of SAS (1992). Means were separated using Duncan Multiple Range Test and least significant difference (LSD) at 5% probability level.

3.3 Experimental layout



Area of each plot=3.75m ^{2} Net plot =2m ^{2}, Total field area =155.25m ^{2}

Fig. 3.1. Field layout showing treatment combinations

Key: Fertilizer treatments:

1,2 = NPK 60kg ha^{-1} and 30kg ha^{-1}

3,4 = NPK 60kg ha^{-1} + Biochar 5kgN ha^{-1} and NPK 30kg ha^{-1} + Biochar 2.5kgN ha^{-1}

5= Contol

3.4 Cocoa pod husk biochar production

Cocoa pod husk biochar production was done through thermal decomposition of cocoa pod husk biochar without oxygen at the Department of Mechanical Engineering, University of Ibadan.

Plate 4: Metal pyrolysis reactor before charred for production of cocoa pod biochar

Plate 5: Dried cocoa pod husk used in the Production of cocoa pod biochar.

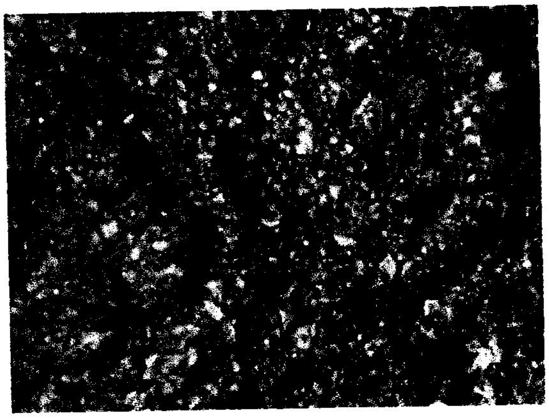


Plate 6: Biochar derived from cocoa pod husk

3.5 Laboratory Analysis

On soil sample the following laboratory analyses were Carried out: pH(1:1 soil / water ratio), particle size ,(sand ,silt , clay),organic carbon , total N, available P(Bray-1-p), and exchangeable Cations (K,Ca,Mg and Na),the exchangeable acidity (EA),The extractable micronutrients (Mn, Fe, Cu and Zn).

1. **The Soil pH**

The pH of the soil was determined in 1:1 soil/ water using the potentiometric method (Richards, 1954).

Apparatus:

Glass electrode

50ml beakers

A glass rod

Reagent:

Distilled water

Procedure:

20g of <2mm sieved sample weighed into 50ml beaker and 20ml of distilled water was added to the beaker . The suspension was stirred in intermittently for 30 minutes and allowed to settle. The pH electrode of the pH meter was inserted into the partly settled suspended to take the pH reading.

3.5.2 Particle size analysis

The particle size analysis was done using Bouycous (hydrometer) method (Gee and Bauder, 1986). To each of the 50g oft >2mm sieved soil weighed into plastic bottles was added 100ml of calgon solution and the suspension were stirred with a glass rod. 100ml of distilled water was added and shaken for ten minutes on a reciprocation mechanical shaker. The suspension were poured into 1000ml of cylinders and made to the mark with water, ensuring that all the hydrometer reading was taken after 40 seconds. The suspension was allowed to stand for two hours after which the second hydrometer reading was taken. A blank reading was determined following the same procedure except that the soil was not added.

The texture was calculated thus:

$$\text{Percentage Clay} = \frac{\text{corrected 2hrs reading} - \text{blank} \times 100}{\text{Weight of soil}}$$

$$\text{Percentage clay} = \frac{\text{corrected 40seconds reading} - \text{blank} \times 100 - \text{\% clay}}{\text{Weight of soil}}$$

Percentage sand = 100-(%clay+ silt)

3.5.3 Organic Carbon

Apparatus

- 50ml burette
- 250ml conical flasks
- 10ml pipette
- 50ml graduated cylinders

Reagent

- K_2CrO_7 -49.04g of potassium dichromate were dissolved inn distilled water and diluted to one litre

- Concentrated H_2SO_4
- O-phenanthroline ferrous complex
- Concentrated H3PO4(orthophosphoric acid)
- 0.5N Fe 804-196.1g. Ferrous ammonium sulphate.
- Fe $(NH_4)_2$ $(SO_4)_3$ $6H_2O$ was dissolved in 800ml distilled water.20ml of conc.

H_2SO_4 was added, shaken vigorously and made up to a litre with distilled water

Procedure

The organic carbon determination was done following the walkely- black (Chromic acid) method (Nelson and Sommer, 1982). About 25g of soil was ground to pass through a sieve. 0.5g was accurately weighed into a 2501 conical flask. 10ml 0f 1.0NK_2 Cr_2O_7 was added using a pipette and swirled to mix. Using a 50ml graduated cylinder 20ml of concentrated $H_2SO_4$was rapidly added, by directly the steam into the suspension. The flask was immediately swirled gently until reagent were mixed, then more vigorously for a total of I minute. The flask was allowed to stand for 30mintes. After this time 200ml of water, 10ml of conc. H_2SO_4 and 3 to 4 drops of O-phenathroline indicator were added. The mixture was titrated to a wine red end point with 0.5N (colour changed from blue to dark green as the end point was approached).

$$\% \text{ Organic carbon} = \frac{(B-T)\times 0.003\times 1.33}{\text{Weight of sample}}$$

Where B=blank reading

T =Tire reading

3.5.4 Organic matter

The organic matter was calculated by multiplying the organic carbon with a factor of 1.724.

3.5.5 Total Nitrogen

The total N was determined by using Macro -Kjeldahl method (Jackson, 1964).0.5g of finely grounded sample was weighed in to 50ml Kjeldahl digestion flask .1.1 g of K_2SO_4 catalyst and 3ml of concentrated H_2SO_4 was added . The flask was heated on a digestion block until frothing subsides. The heat was gr adually ncreased until a clear digest was obtainted . The mixture was further heated for another 3-5 hours . The flask was cooled and 20ml of distilled water was slowly added with shaking swir . The whole digest was then transferred to a Kjeldahl distillation flask marked 80ml.

The total Nitrogen is calculated thus:

$$\text{Total N (mgkg-1 soil)} = \frac{(\times 3 - \times 1)\ 100}{\times 2,\ Y}$$

3.5. 6 The Available P

Available phosphorus was determine by Bray- 1-P (Bray and Kurtz., 1945) method 1g of air dried <2mm sieved soil sample was weighed into 50ml centrifuge tubes with stopper and 7ml of extractant (HCL-NH_4F solution) was added to each . The suspensions were shaken for 1 minute and centrifuged at 3500rpm for 5 minutes. The suspensions were filtered to get a clear filtrate. 2ml of the titrate was transferred into a 25ml container, 4ml of the developer (a mixture of ammonium molybdate reagent and ascorbic acid solution) was added and the solution were made to mark with water. The solution were left for10 minutes after which the colour development was measured in the same way.

The available phosphorus ($Mgkg^{-}1$) was calculated thus:

$$Mhkg^{-}1 = \frac{R \times G \times VE \times DF}{W \times \text{Aliquot}}$$

Where, R= Abssorbance

G= Gradient of the standards

VE= volume of extractant

DF= volume of container

W= weight of sample taken

3.5.7 Exchangeable bases

Exchangeable bases (Ca, K and Mg) were extracted with 1N ammonium acetate at pH 6.58. Potassium was read using flame photometer while Ca and Mg were determined using Atomic Absorption Spectrophotometer.

3.5.8 The Exchangeable Acidity

This was done using the method described by juo(1979). 10g of the air. dried<2mm sieved samples were weighed into a funnel fitted wicth a what man No -1 filter paper fixed into100ml plastic bottles .the samples were taken into a 250ml beaker and 5 drop of phenolphthaline indicator was added . The solution were titrated with 0.1 N NaOH solution to a permanent pink end the titre value were recorded. Blank determination was also done following the procedure above but no soil was added.

The exchangeable acidity (Meq100g⁻1soil) = $\frac{(T-B)\times NB\times VE\times 100}{W\times \text{Aliquot taken}}$

Where T= Titre

B= blank reading

NB= normality of base

VE= volume of extract

W = weight of soil taken

3. 5. 9 Cation Exchange Capacity

Exchangeable Cation were determined by IN NH40Ac at pH7. The K was determined by the flame photometer, while Ca, Mg, and Na were determined by atomic Aborption spectrophotometer (AAS). The exchangeable Cation capacity (CEC) was determined by the ammonium saturation method.

The ECEC was then calculated as the sun of the exchangeable bases and exchangeable acidity (Juo, 1979).

3.5. 10 Base saturation

Base saturation was calculated as the sum of the exchangeable bases expressed as the % of the CEC.

$$\% \text{ base saturation} = \frac{K+Na+Ca+Mg}{CEC}\times 100$$

3.5. 11 Extractable micronutrient

The extractable micro nutrient (Mn, Fe,Cu and Zn) were determined by extracting with 0.1N Hcl and read on Atomic Absorption Spectrophotometer(AAS).

CHAPTER 4

RESULT AND DISCUSSION

4.1 Soil characteristics.

Results of the initial chemical and physical analysis are presented in Table 4.1. The detailed physico-chemical characteristics as shown revealed the soil pH 6.08 is slightly acidic. The classification of the experiment site where the field work experiment and land use description revealed that the land use pattern was predominantly mosaic forest cropped principally to cassava/maize and yam in the upper crest of the slope. These soils maintained cacao and most food crops. The soil is classified as Alfisols, having good base saturation (more than 35% with a distinct /argillic (clay accumulation B horizon), slightly and moderately acidic, 1.5m below the top (Bromfield ,1967).

The soil is low in organic matter (5.34g kg^{-1}) .the total N (0.6g kg^{-1}) is considered low, considering 1.0g kg^{-1} critical level established by Metson (1961). The exchangeable bases in order of their abundance were: Mg (1.89)>Ca (0.35) >Na (0.61) P > (0.06) c $molkg^{-1}$. The Ca was low considering critical level 2.0-2.6 c mol g^{-1} soil established by Agboola and Corey (1973) and 3.8c $molkg^{-1}$ soil by Agboola and Ayodele (1987) Mg considered low compared to 1.9 c mol kg^{-1} soil established by Agboola an Ayodele (1987) and K considered low compared to 0.18 -0.2 c mol kg^{-1} soil by by Agboola and Obigbesen (1974). The extractable micronutrients in order of their abundance were: Fe (65.35)> Mn (39.47)>(3.45) >Cu(1.67mgkg $^{-1}$) . The Mn was high with 25mgkg $^{-1}$ critical level by Agboola and Adeoye (1985). Zn content was moderate with 3.0 - 3.45 $mgkg^{-1}$ critical level by Sobulo and Osiname (1981). High content of extractable micronutrient are toxic to plant and deleterious effect on plant nutrition. The exchangeable acidity (0.05) was low. The CEC (1.65c mol kg^{-1}) is low compared with >4 c mol kg^{-1} critical level established by FAO (1979). The available P (162) Mg kg^{-1} was deficient considering 8-25$mgkg^{-1}$ critical level by Adepetu and Barber (1979).

The low native available Pin this forest soil could be attribute to low soil organic matter which is characteristic of acid mineral soils of the basement Complex as explained by Agboola and Oko (1976) and Mengel (1997)

Table 4.1: Characteristic of the soil used for the studies

Properties	Values
pH H_2O (1:1)	6.08
Org. C (g kg^{-1})	3.1
SOM (g kg^{-1})	5.33
Total N (g kg^{-1})	0.6
Av. P Bray 1(mg kg^{-1})	16.2
Exchangeable Cations (c mol kg^{-1})	
K	0.06
Ca	0.35
Mg	1.89
Na	0.61
Exch. Acidity	0.05
ECEC	2.96
Base saturation%	90.3
Extractible micronutrient (mg kg^{-1})	
Cu	1.67
Zn	3.45
Mn	39.47
Fe	65.35
Particle size (g kg^{-1})	
Sand	615
Silt	212
Clay	173
Textural class	Loamy sand

4.2 Chemical property of Biochar used for the experiment

The chemical composition of Biochar derived from Cocoa pod husk in Table4.2 with regard to the tissue nutrient concentrations when compared to reported value of other sources of organic matter. The NPK 20:10:10 applied at 60kgN/ha fortified with 5tons/ha of biochar consistently improved N, P and K uptakes better than other treatments and significantly enhanced the N uptakes better than NPK fertilizer applied without biochar as indicated in Tables4.2.

Biochar when added to soil has been reported to increase available nutrients and prevent their leaching, stimulate activity of Agricurally important soil Microorganism and enhance the mineral fertilizer use efficiencies (lehmann 2007b)

Table 4.2: Chemical properties of Biochar derived from cocoa pod husks used for the experiment

Parameter	Values
pH	7.9
Org. C (g kg^{-1})	7.02
Nitrogen (g kg^{-1})	4.58
Phosphorus (g kg^{-1})	0.5
Potassium c mol kg^{-1}	0.66
Calcium (g kg^{-1})	2.89
Sodium c mol kg^{-1}	0.64

4.3 Effect of Fertilizer source on growth of Okra

The plant height was highly significant ($p<0.001$) during the growth period (Fig.4.1). This indicated that each treatment release nutrients that enhance plant height of Okra. From the figure above, at 2 weeks the height was highest in NPK@60kg + biochar (5 kgN/ha) with a height of 8.32cm. This was followed by NPK 60kg with a height of 7.37cm. The least height was recorded in NPK 30kg at the height of 6.86cm. There was a significant increase in the heights of the plants from 2 weeks to 8 weeks. At maturity, after 8 weeks, the heights of the plant were highest at the treatment of NPK (60kg) + Biochar (5 $kgNha^{-1}$) at a height of 46.72cm. This was followed by NPK (60kg), NPK (30kg), NPK (30kg) + Biochar (5 $kgNha^{-1}$) and Control at 43.69cm, 39.26cm, 33.60cm and 29.35cm respectively. However, the Okra plant responded favorably to the Biochar derived from cocoa pod husk (organic source) treatment compared to other treatment. This may suggest that the organic residue may have contributed some micronutrients. This observation is in agreement with that of (lehmann 2007b). Who reported that the residual effect of organic fertilizer increase in height.

Figure 4.2 showed effect of fertilizer source in okra stem. ($p<0.001$) effect on stem girth was observed. In respect to the stem girth at maturity, the stem girth was in the range of 0.74 and 1.08m. The treatment that had Okra stem with the highest stem girth was NPK (60kg) + Biochar (5 $kgNha^{-1}$) at a stem girth of 1.08cm while the least stem girth of 0.74 was recorded for the control. The other treatments recorded stem girth in between these extremes. All treatment had a significant ($p< 0.001$) effect on the stem girth however; NPK (60kg) +Biochar (5kgN) had the highest (fig4.2). The finding of this study agree with (kang and Balasubramanian 1990) who reported that inorganic fertilizer at higher rate ($NPK60kgha^{-1}$ +Biochar 5kgN ha^{-1}) did not significantly ($P< 0.05$)affect the stem girth of Okra plant compare to the lesser rate $NPK30kg/ha^{-1}$ +Biochar $2.5kgNha^{-1}$ of same fertilizer treatment.

Figure 4.3 show the effect of fertilizer sources on the number of leaves. There was significant ($p<0.001$) effect on the number of leaves for all the treatments. Generally there was an increase in the number of leaves. However, the number of leaves under the highest for the treatment of NPK (60kg) + Biochar (5kgN ha^{-1}) at 10 leaves per plant. This was followed by

NPK (60kg), NPK (30kg) + Biochar (2.5kgNha^{-1}), NPK (30kg) and Control at 9, 7, 7 and 7 leaves respectively. This implies that the number of leaves was affected by the type of fertilizer applied as the number of leaves varied with respect to the fertilizer used. This observation was agreed with (Lehmann, 2007b).

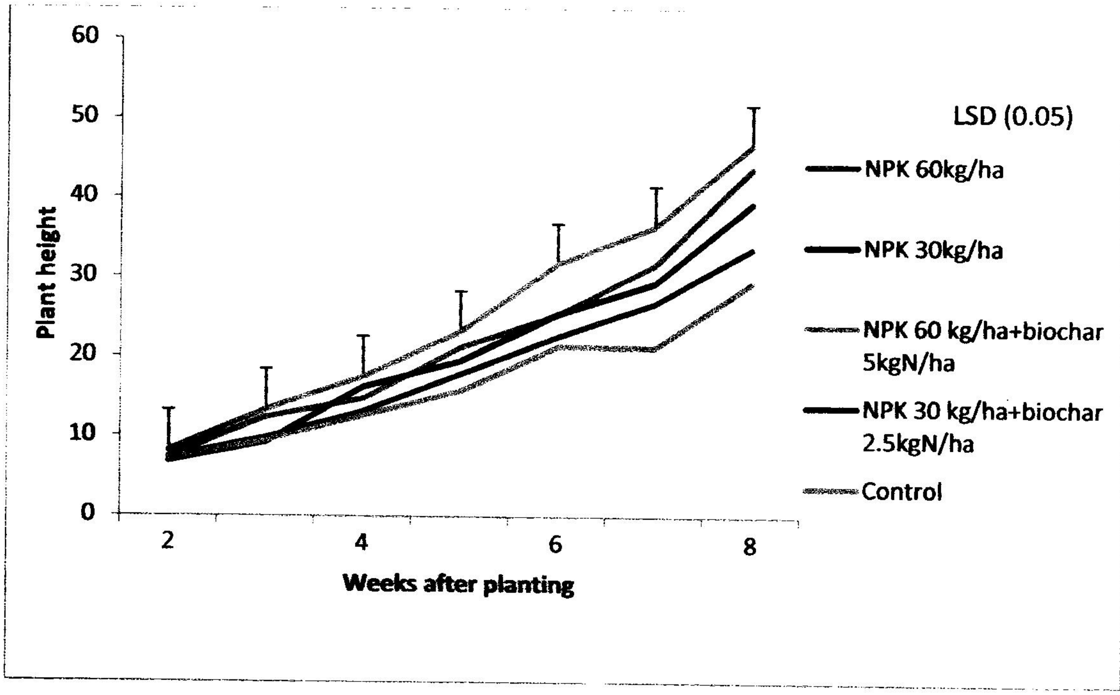


Fig 4.1: Effect of Biochar and inorganic fertilizers on plant height of okra

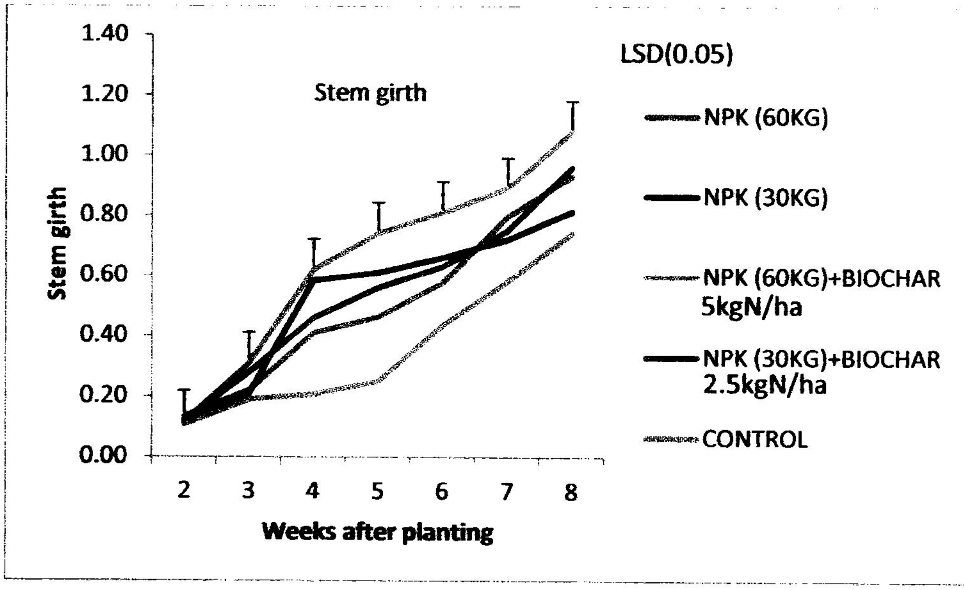


Fig 4.2: Effect of Biochar and inorganic fertilizers on stem girth of Okra.

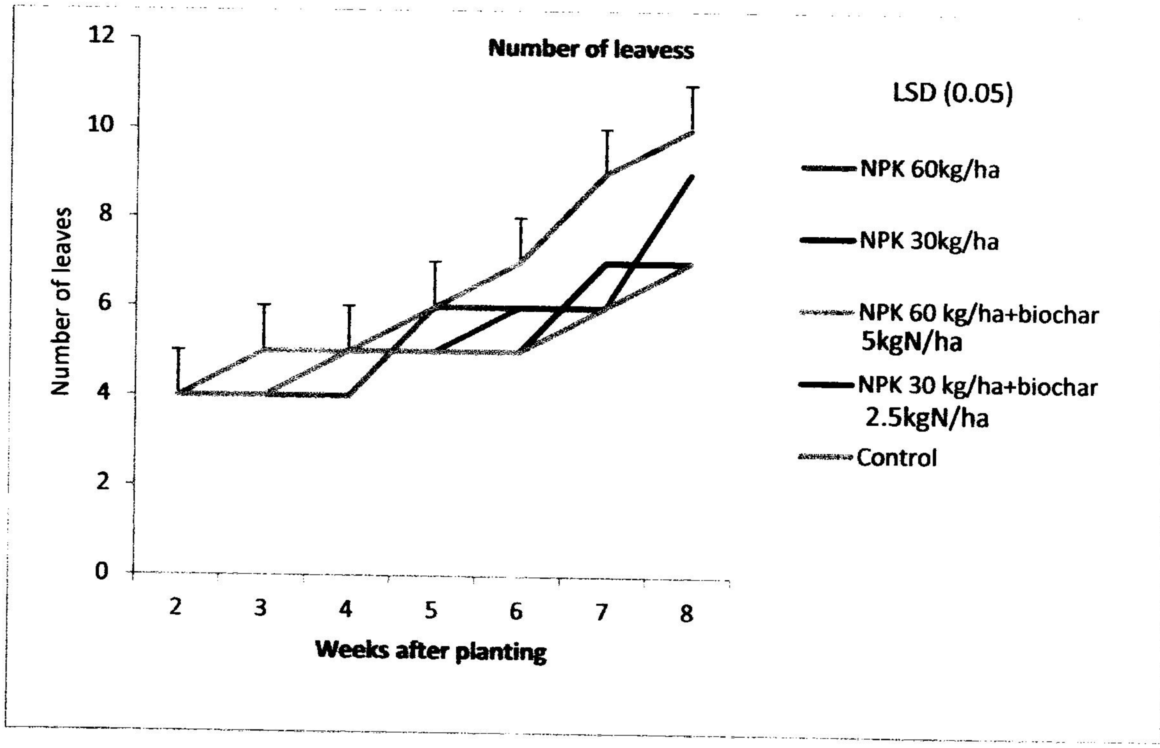


Fig 4.3: Effect of Biochar and inorganic fertilizer on number of leave of Okra.

4.4 Effect of fertilizer source on biomass of Okra

The effect of fertilizer source on dry biomass of Okra is showed in Table 4.3 and significant at (P< 0 .005) treatment effect on dry biomass was observed on Okra plant. The Organic fertilizer showed not to be significant. Also the combination of NPK fertilizer and Biomass tested on Okra plant showed not to have influence over the biomass even as they are not significantly from one other.

Table 4.3: Effect of fertilizer sources on Okra biomass production

Fertilizer sources	Rate	Biomass	Produced	(kg/ha)	
		weeks	After	Planting	
		3	4	5	6
NPK	60kg/ha	5.86	5.70	6.64	13.98
NPK	30kg/ha	6.69	6.63	7.45	7.00
NPK + biochar	60/ha +5kgN/ha	5.28	6.52	8.10	3.67
NPK +biochar	60/ha +2.5kgN/ha	6.24	5.03	5.30	8.34
Control	-	5.41	3.98	6.10	7.43

Means with the same superscript in each column are not significantly different at $P < 0.05$

4.5 Nutrient Uptake

Nutrient uptake effect of fertilizer source on Okra is shown in Table 4.4 at 4WAP. There were significant ($P<0.0001$) different for Nitrogen, phosphorus and potassium uptake very low coefficient of variation. The NPK 20:10:10 applied at 60kg/ha fortified with 5kgN/ha of biochar consistently improved N, P and K uptakes better than other treatments and significantly enhanced the N uptakes better than NPK fertilizer applied without biochar as indicated in Table 4.4. Biochar when added to soil has been reported to increase available nutrients and prevent their leaching, stimulate activity of agriculturally important soil microorganisms and enhances the mineral fertilizer use efficiencies (Lehmann 2007b).

Table 4.4: Effect of fertilizer source on NPK uptake at 4weeks after planting

Fertilizer sources	Rate	Uptake (kg/ha)		
		N	P	K
NPK	60kg/ha	16.17b	2.97ab	4.83ab
NPK	30kg/ha	10.37b	2.13b	3.33ab
NPK + biochar	60/ha +5kgN/ha	27.47a	4.47a	5.13a
NPK +biochar	60/ha +2.5kgN/ha	18.23ab	2.90ab	4.6ab
Control	-	9.3b	1.87b	2.73b

Means with the same superscript in each column are not significantly different at $P < 0.05$

4.6 Variation in post –cropping soil characteristic with fertilizer source

Effect of varying rate of NPK 20:10:10 applied at 60kg/ha in combination with 5 kgN of biochar/ha resulted in higher values of soil pH, total nitrogen, organic carbon, available phosphorus, exchangeable Potassium, Calcium and Magnesium at the end of the trial(Table4. 5) compared with other treatments. Soil total nitrogen values at the end of the trial for the control and NPK fertilizer treatments were lower than the initial value while NPK fertilizers used in combination with biochar resulted in higher soil total nitrogen values when compared with the initial soil N value in Table 4.5). This might be due to reduced leaching of nutrients when mineral fertilizer is applied in combination with biochar as reported by Lehmann 2007b.

Table 4. 5. Variation in Post – Cropping Soil pH With Fertilizer Source

Fertilizer sources	Rate	value	
		Pre.-cropping	post- cropping
Control	0	6.08	6.07
NPK	30kg/ha	6.08	6.08
NPK	60kg/ha	6.08	6.09
NPK +Biochar	60kg/ha+5kgN/ha	6.08	6.72
NPK +Biochar	30kg/ha + 2.5kgN/ha	6.08	6.67

Table 4.6. Variation in Post – Cropping Soil Nitrogen with Fertilizer Source

Fertilizer source	Rate	value	
		Pre.-cropping	post- cropping
Control	0	0.6	0.3
NPK	30kg/ha	0.6	0.5
NPK	60kg/ ha	0.6	0.4
NPK + Biochar	60kg/ha+5kgN/ha	0.6	0.9
NPK + Biochar	30kg/ha +2.5kgN/ha	0 .6	0.7

Table 4.7. Variation in Post – Cropping Soil Phosphorus with Fertilizer Source

Fertilizer source	Rate	value	
		Pre.-cropping	post- cropping
Control	0	16.2	14.3
NPK	30kg/ha	16.2	17.4
NPK	60kg/ha	16.2	20.2
NPK + Biochar	60kg/ha+5 kgN/ha	16.2	21.4
NPK + Biochar	30kg/ha+2.5 kgN/ha	16.2	21.1

Table 4.8. Variation in Post – Cropping Soil Potassium content With Fertilizer Source

Fertilizer source	Rate	value	
		Pre.-cropping	post- cropping
Control	0	0.06	0.43
NPK	30kg/ha	0.06	2.24
NPK	60kg/ha	0.06	1.09
NPK+Biochar	60kg/ha+5kgN/ha	0.06	3.69
NPK +Biochar	30kg/ha +2.5kgN/ha	0.06	2.85

Table 4.9. Variation in Post – Cropping Soil Calcium Content with Fertilizer Source

Fertilizer source	Rate	value	
		Pre.-cropping	post- cropping
Control	0	0.35	4.95
NPK	30kg/ha	0.35	5.27
NPK	60kg/ha	0.35	5.08
NPK+Biochar	60kg/ha+5kgN/ha	0.35	8.12
NPK+Biochar	30kg/ha +Biochar2.5kgN/ha	0.35	6.49

Table 4.10 Variation in Post – Cropping Soil Magnesium content With Fertilizer Source

Fertilizer source	Rate	value	
		Pre.-cropping	post- cropping
Control	0	1.89	0.81
NPK	30kg/ha	1.89	3.22
NPK	60k/ ha	1.89	2.03
NPK+ Biochar	60kg/ha+5kgN/ha	1.89	2.98
NPK +Biochar	30kg/ha +2.5kgN/ha	1.89	2.87

4.7 Okra fruit yield as affected by fertilizer sources

The fresh fruit yield of Okra obtained under NPK 20:10:10 applied at 60kg/ha in combination with 5 kgN/ha of biochar was significantly higher than what was obtained in other treatments (Table 4.11). Kang and Balasubramanian (1990) affirmed that high and sustained crop yield can be obtained through the combination of NPK fertilizer and Biochar. Agboola and Odeyemi (1993) noted that the use of inorganic fertilizer alone has been ineffective in the maintenance of soil fertility in Nigeria. This could be attributed to low Cation Exchange Capacity (CEC) of the most of the soil which implies low nutrient holding potentials.

Table 4.11: Okra fruit yield as affected by fertilizer sources at 16weeks of growth

Treatment	Okra fresh fruit yield (kg/ha)
NPK60kg/ha	14,422.83b
NPK30kg/ha	12,910.53bc
NPK60kg/ha+5kgN/ha biochar	25,707.40a
NPK30kg/ha+2.5kgN/ha biochar	9,598.9c
Control	9,077.10c

4.8 Economic Analysis of the production Okra fruits per hectare

Table 4.12 to 4.15 showed that there are five treatments and the component of each of the treatments is as shown in the Table. The analysis of the variable costs for the project is shown in Table 4.13. In the table, the cost of weeding is the highest in the five treatments followed by the cost of land clearing while the cost of procuring Okra seeds for planting was the third highest variable cost. However, the total variable cost was the highest in treatment NPK 60kg/ha+Biochar 5kgN/ha with a sum of ₦1,451,047.62 per hectare and that of treatment 5 (which is the control experiment) was the least with a sum of ₦751,047.62 per hectare. This wide variation was confirmed by the result of the Analysis of Variance (ANOVA) carried out on the variable costs among the treatments. The result shows that critical of 2.8164 is greater that value of 0.3831 showing that there is significant difference in the variable costs among the treatments.

Table 4.13 Analysis of variable costs for producing Okra per hectare

Variable items	Costs (₦)				
	NPK 60kg/ha	NPK 30kg/ha	NPK 60kg/ha +Biochar 5kgN/ha	NPK 30kg/ha +Biochar 2.5kgN/ha	Control
NPK fertilizer	60,000.00	30,000.00	60,000.00	30,000.00	0
Biochar	0	0	600,000.00	300,000.00	0
Okra seeds	119,047.62	119,047.62	119,047.62	119,047.62	119,047.62
Land clearing	125,000.00	125,000.00	125,000.00	125,000.00	125,000.00
Field layout	50,000.00	50,000.00	50,000.00	50,000.00	50,000.00
Planting	40,000.00	40,000.00	40,000.00	40,000.00	40,000.00
Weeding	225,000.00	225,000.00	225,000.00	225,000.00	225,000.00
Fertilizer application	40,000.00	40,000.00	40,000.00	40,000.00	0
Harvesting	80,000.00	80,000.00	80,000.00	80,000.00	80,000.00
Salesmanship	48,000.00	48,000.00	48,000.00	48,000.00	48,000.00
Transportation	64,000.00	64,000.00	64,000.00	64,000.00	64,000.00
Total Variable Costs	851,047.62	821,047.62	1,451,047.62	1,121,047.62	751,047.62

4.9 Analysis of revenue per hectare

Table 4.14 shows the analysis of revenue per hectare for all the treatments. The result shows that the revenue from Treatment 3 is the highest with a sum of ₦6,426,850.00 per hectare. This is followed by that of treatment 1 which is ₦3,605,707.50 per hectare while the least revenue was from treatment 1 (₦2,269,275.00). The result follows the trend of variable costs.

Table 4.14: Analysis of revenue per hectare

Treatments	Yield (Kg/ha)	Price (₦)	Revenue (₦)
NPK60kg/ha^{-1}	14,422.83	250	3,605,707.5
NPK30kg/ha^{-1}	12,910.53	250	3,227,632.50
NPK60kg/ha^{-1} +5kgN/ha biochar	25,707.40	250	6,426,850.00
NPK30kg/ha^{-1} +2.5kgN/ha biochar	9,598.00	250	2,399,500.00
Control	9,077.10	250	2,269,275.00

4.10 Gross Margin Analysis

Table 4.15 shows the result of Gross Margin Analysis (GMA) for all the treatments. Gross margin is the difference between the total revenue and the total variable costs. If the gross margin is greater than one, then the project is profitable. However, looking at the result in Table 4.15, the gross margin for all the treatments are greater than 1 showing that all the treatments are profitable economically. However, Treatment 3 had the highest gross margin of ₦4,975,802.38 per hectare. Meanwhile, this does not translate to the real profit until the cost of fixed inputs and the tax are deducted from it. However GMA is an indices that the project is profitable. The treatment with the least gross margin was Treatment 5 (which is the control experiment) with the value of ₦1,518,227.38. Generally, the result of Gross Margin Analysis shows that Okra cultivation using any of the treatments is profitable; however treatment NPK 60kg/ha+Biochar 5kgN/ha was most profitable.

Table 4.15. Gross Margin Analysis

Items (₦)	NPK 60kg/ha	NPK 30kg/ha	NPK 60kg/ha +Biochar 5kgN/ha	NPK 30kg/ha +Biochar 2.5kgN/ha	Control
Total Revenue	3,605,707.50	3,227,632.50	6,426,850.00	2,399,500.00	2,269,275.00
Total Variable Costs	851,047.62	821,047.62	1,451,047.62	1,121,047.62	751,047.62
Gross Margin	2,754,659.88	2,406,584.88	4,975,802.38	1,278,452.38	1,518,227.38

4.11 Benefit-Cost Ratio (BCR) Analysis

Table 4.16 shows the result of Benefit-Cost (B:C) ratio analysis. Benefit-Cost ratio is the ratio of the discounted benefits to the discounted costs. Discounted benefits and costs are the revenues and costs after they have been treated with discount factor. If the ratio is greater than 1, then it shows that the project is profitable. The result in Table 4.16 shows that the B:C for all the treatments are greater than 1 showing that all the treatments are profitable. However, the B:C for treatment 3 is the highest of them all showing that treatment 3(NPK 60kg/ha+biochar 5kgN/ha) is the most profitable of all the treatments. Generally, the result also shows that Okra cultivation using all the treatments is profitable while that of treatment 3(NPK 60kg/ha+biochar 5kgN/ha) is the most profitable.

Table 4.16. Benefit-Cost Ratio (BCR) Analysis

Treatments	Discounted Benefit	Discounted Cost	B:C
NPK60kg/ha^{-1}	2,812,451.85	663817.14	4.24
NPK30kg/ha^{-1}	2,517,553.35	660417.14	3.81
NPK60kg/ha^{-1}+5kgN/ha biochar	5,012,943.00	1,131,817.14	4.43
NPK30kg/ha^{-}1+2.5kgN/ha biochar	1,871,610.00	997,192.86	1.88
Control	1,770,034.50	585817.14	3.02

CHAPTER 5

SUMMARY, CONCLUSION AND RECOMMENDATION

The growth parameter measured were significantly ($P<0.05$) higher for treatment 60kg NPK fortified with Biochar 5kgN/ha compared to other treatments. The Okra fruit yield was also significantly ($P<0.05$) higher for NPK fertilizer 60kg/ha fortified with Biochar 5kgN/ha with comparison to other treatments. This treatment also had the highest benefit/cost ratio. The Economic analysis indicated the superiority of this treatment component to other treatments. This showed the combination of NPK and biochar at this of NPK and biochar at this level is the most profitable.

This rate could be recommended to farmer for profitable production of Okra based in the findings of this research

REFERENCES

Akoroda M.O (1982). Harvest duration and edible fruit yield of Okra. *In \Okra improvement. Annual report. NIHORT Ibadan. Pp44.45.*

Ali, A (1999) Response of okra (A.esculentus (L) (Moench) phosphorusand spacing, M.Sc thesis. Department of Horticulture, university of Agriculture.

Akoma, U.M.(1985). Soil organic matter and its conservation for increase in productivity of vegetables in Nigeria University of Ife *Pp228.*

Agboola and Odeyemi (1993). A review of soil fertility in southwest zone of Nigeria federal Department of Agriculture land resource (FDAIR), kaduna ,Nigeria report. Number 6, *pp.3-9.*

Agbool. A.A and Corey, R.B.1973. Soil testing NPK for Okra in the soil derived from Metamorphic and igeous rock of westen State of Nigeria. *Journal west African Science Association. 17.2:93-100*

Agboola. A.A and Obigbesan, G.O. 1974. The response of some improves food crop varieties of Fertilizer in the forest zone of western Nigeria . In port of FAO/ NOPARD/ EDA Seminar of fertilizer use in Nigeria, Ibadan. *Pp.1-9.*

Agboola ,A.A and Adeoye G.O 1985, soil fertility problem and its management in tropical Africa. Paper presented at the international of Tropical Agriculture Ibadan , Nigeria p.25

Alennder (1993). Modern Trend in special fertilization practice Word Agriculture *35-38.*

Application to Soils - A Critical Scientific Review of Effects on Soil Properties. Process Funct. doi:*10.2788/472.*

Ayuso, M. A. Pascal, J. A. Garcia C. and Hernandez, 1996. Evaluation of urban waste for Agricultural use. *Soil Science plant Nutrition 42:105-111.*

Bemire,A.S. and J,F(2003) profitability of vegetable farming under rainy and dry season Production in South western Nigeria .*Journey of vegetable crops production 9:11:18.*

Bray ,R.H and Kurtz L.T(1945) determination of total organic and available forms of Phosphorus in soils. *Soil science59:39-45.*

Bromfield , A.R. 1967. End of tour report soil and chemistry section research division western state. Ministry of Agriculture and Natural resources, Ibadan

Clemson university production (2003). Rearing okra. Issued in furtherance of cooperative extension work in Agric. And Home economics, exerted from Home vegetable garden *Ec270.*

Carter , M.R.1992 influence of reduced tillage system on organic matter, microbial biomass ,macro –aggregate distribution and structural stability of surface soil *in the humid climate. Soil tillage Reseach. 23:361-372.*

Cheng Nekka, S.B.R 2011: sustainability of Biochar system developing countries. Published in international Biochar initiative (IBI). *Carter (1993).*

Eke, K.A, Essien B.A. and J.u Ogbu(2008).Determination of optimum planting time of Okra in *the derive savannah. Proc. of the 42nd conf. of ASN at Abbakaliki 17th -23nd Oct 2008. Pp 242-245*

El-Shakweer, M.H.A., El – Sayed, E.A. and Ewees, M.S.A, 1998. Soil and plant analysis As a guide for interpretation of the improvement efficiency of organic Conditioners added to different soil in Egypt. Communication Soil Science Plant.

FAO (2005). Food and Agricultural of okra organization of the united Nation FAOSTAT Data, 2005.

FAO (2005) FAOSTAT statistical data base (URL: http//apps. Fao.org/ default .hmt) Retrieved 26th June, 2005.

Fatokun,C.A and Chedda,H.R(1983): The effects of nitrogen and phosphorus on yield

And chemical composite Okra. Abelmoschus esculentus.

Flaig . W.1975. biochemistry of soil organic matter. In organic materials as fertilizer.FAO soil Bulletin *27, 31-69*

Fatokun,C.A(1976). Genetic and agronomic studies of okra. Abelmoschus esculentus Ph.D. Thesis University of Ibadan, Nigeria.

Food Science and Quality Management, 2014, "Nutritional Quality and Health Benefits Of Okra (Abelmoschus esculentus): A Review"

Gibben. D.and A Pain (1985). Crop of the drier regions of the tropics. Intermediate. Tropical Agriculture science. Long man, London. *Pp137.*

Gibbon 1977,FOS,1991)

Glaser, B., lehman , J., Steiner, T,. Nehis, M.Yousaf,and Zech, W. 2002a. Potential of pyrolysed organic matter in soil amelioration . In: people's Republic of China Ministry of Water Resources (ed) 12% International soil conservation Organization conference . Beijing, china

Hammes K, Schmidt M (2009). Changes in biochar in soil. *In: Biochar for Environmental Management Lehmann J, Joseph S (Eds.).Earthscan, pp 169- 182.*

King and Balasubramalna if (1990). Long Effect manure charcoal and mineral fertilizer Crop production fertilizer on upland soil and plant soil *291:275-290.*

Karhu, mattita, T,. Bergstrom,. And Regina,k 2011. Biochar addition to agricultural Increased CH_4 uptake and water holding capacity: results from a short – Term pilot field study. Agriculture, Ecosystems and Environment, *Vol.140;309-313.*

Koutcheiko S, Monreal CM, Kodama H, McCracken T, Kotlyar L (2007). Preparation And characterization of activated carbon derived from the thermo-chemical Conversion of chicken manure. Bio resource. Technol. *98: 2459-2464.*

Lombin L.G Adepetu J.A., Ayotade, A.K (1991) organic fertilizer in the Nigeria Agriculture present and future F.p. D.D Abuja app *146-162.*

Lehman, Johannes 2009. Energy balance and emission association with Biochar Sequestration and pyrolysis Bio energy production.

Lehmann J. and joseph, S .2009a. Biochar for Environmental Management: An Earthscan publications *Ltd, p.1-12.*

Lehmann J. 2007b. Bio-energy In: The black frontiers in Ecology and the Environment 5:381-387.

Lehmann J, Rillig MC, Thies J, Masiello CA, Hockaday WC, Crowley D (2011). Biochar effects on soil biota: a review. Soil Biol. Biochem. *43, 1812-1836.*

Novak, J.M., *et al,* (2009). Impact of biochar amendment on fertility of a southeastem Coastal palm soil .soil science *174(2), p.105.*

NIHORT,(1979): Annual reports: Natural Horticultural Research Institute, Ibadan. USDA, "Okra Grades and Standards"standards/Okra-grades-and-standards.

Obatolu, R.C. 1995 .Nutrient –Balance sheet coffee and maize cropping on an Alfisol Supplied with organic fertilizer in Ibadan –Nigeria African soiln *28:219.224*

Obigbesan, G.O. 1970. Investigation on p status of soil of west and central Africa and The effect of different phosphate fertilizer .PhD .justus university, Giessen, Germany. X 98pp

Ogunlade M.O, Odesola I.F, Mofolasayo A.S, and Adeyemi E.O, (2011): Biochar production from cocoa pod husk for carbon sequestrstion, preliminary Investigation pp72-75.

O. U. Ogbonnaya,*ac O. O. Adebisibc and K. T. Semple The impact of biochar on the bioaccessibility of14C- phenanthrene in aged soil

Richards,L.A(1954), Diagnostic and impromement of saline and Alkaline soils. Agricultural handbook 60. US. Department of agriculture Washington D.C. PP 160.

People, C.O Lehman pp 4152 note 3 .This result in increased crop yield in low input agriculture and increase crop yield per unit of fertilizer applied (fertilizer deficiency) in high input agriculture as well as reduction in offsite effect. Such as run-off, erosion and gaseous losses.

Pessenda LCR, Gouveia SEM, Aravena R (2001). Radiocarbon dating of total soil Organic matter and humin fraction an its comparison with 14C ages of fossil Charcoal

Schmidt MWI, Skjemstad JO, Jager C(2002). Carbon isotope geochemistry and nano Morphology of soil black carbon: Black chernozemic soils in central Europe Originate from ancient biomass burning. Glob. Biogeochem.Cycles, 16, 1123.

Sobulo, R.A and Osiname , O.A.1981. Soil fertility uses in western Nigeria bulletin. 11. L.A.Rand t.Ibadan

Zwieten V.L. Kimber S., Morris. chan, Y.K., Dowinie A., Rust , J 2010. Effect of biochar from slow pyrolysis of paper mill waste on agronomic performance And soil fertility.plant Soil *327: 235-246.*

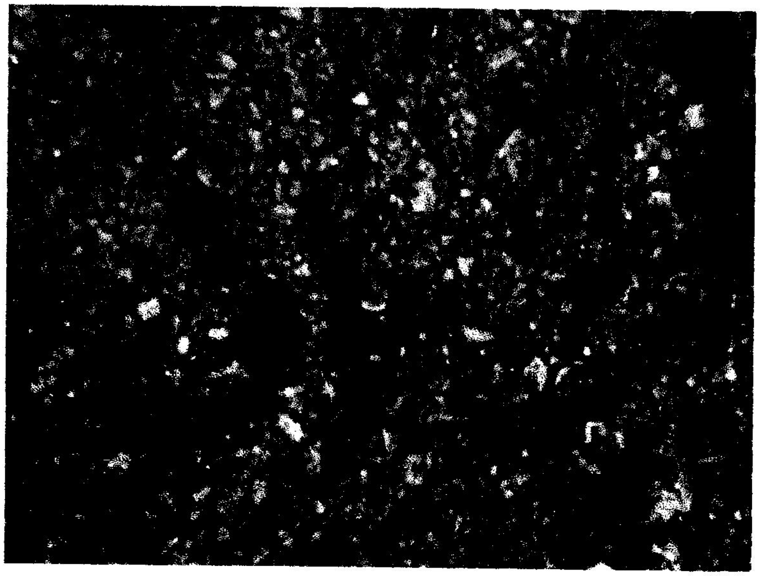
Zhang, A., liu Y., plan, G., Hussain Q., Li, L., Zhen,J. and Zhang, X. 2011. Effect of biochar amendment on okra plant.*vol.351:263-275.*

Verheijen F, Jeffery S, Bastos AC, Velde MVD, Diafas I (2009). Biochar

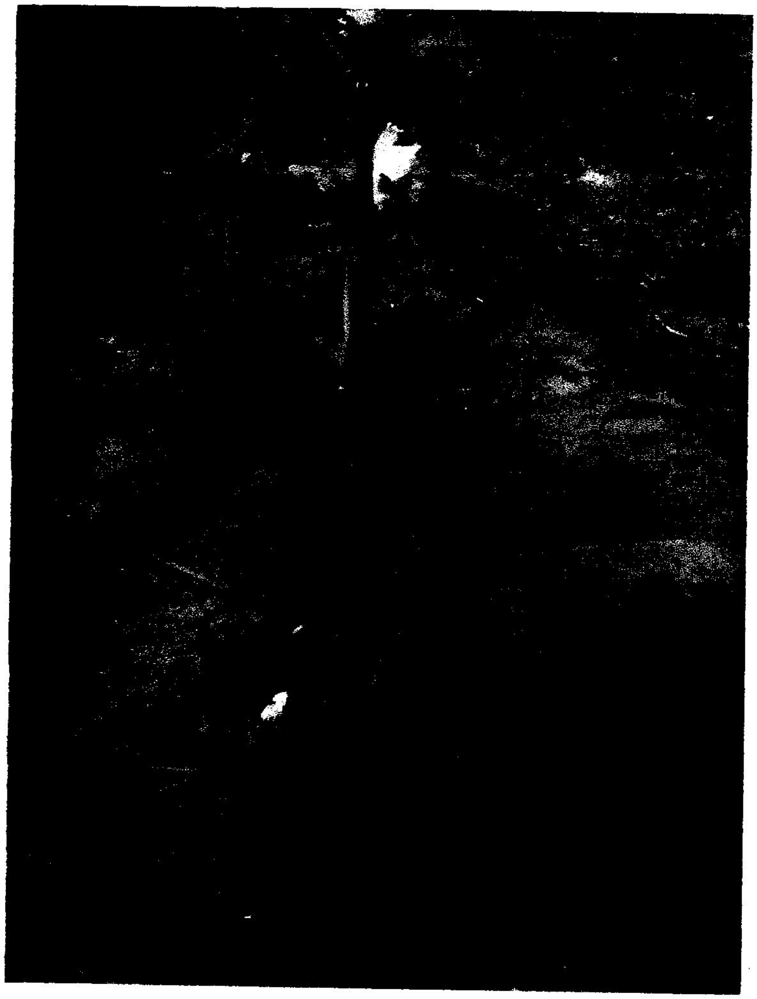
Walkley, A. and Black, L.A (1934) , An examination of the Degtjareff method for determing soil organic matter and proposed modification of the chromic acid Titration method. Soil science *37:29-38.*

APPENDIX

Appendix 1: Dried cocoa pod husk before charred


Appendix 2 .Dried cocoa pod husk CPH being charred on biochar stove

Appendix 3.Biochar production from dried cocoa pod husk CPK after 55 minute



Appendix 4. Okra NPK60kg/ha^{-1}+5kgN/ha biochar