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(Research Article)

Physical and chemical assessment of charcoalized soil on the field performance of maize (*Zea mays*)

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Abstract

This study investigated the effects of charcoalized soil on maize and cowpea which was conducted in the Green House of the Science Laboratory Technology in The Oke-Ogun Polytechnic. The treated seeds of maize was planted in plastic containers containing 4.2g of charcoalized soil in the Green House. The result obtained showed that sample E with manure had the highest stem height (40.69) while sample E with manure has the lowest value (8.97). It further revealed that the leaf length ranged from 60.14 to 24.52, Sample E with manure has 60.14 while sample B without manure had the 24.52 which is the lowest leaf length among the samples. Number of leaves ranged from 9.04 to 5.42mm, sample E with manure has the highest values while sample A without manure had was the lowest value. It revealed that there was no significance difference in cadmium and cobalt contents. It further reveled that Sodium ranged from 0.69 to 0.007, Sample B with manure having the highest sodium contents while Sample B without manure having the lowest sodium contents. Calcium ranged from 19.0 to 0.007, Sample B without manure having the highest calcium contents while sample E without manure having the lowest calcium contents among the samples. However, the efficiency of biomass conversion into charcoal was important in conjunction with a newly proposed opportunity to use charcoal as a soil conditioner that improves soil quality on very acid and highly weathered soils. It is hereby recommended that in other to improved nutrient contents, particularly in C^+, resulted in a significant cowpea yield increase and further field-testing of charcoalized soil should be continued for three or more growing seasons to see the trends in yield, so as to ascertain the long-term effects of charcoal production on the fertility of tropical soils.

Keywords: Charcoalized-Soil; Green House; Biomass; Manure; Weathered- Soil

1. Introduction

In Nigeria, most rural dwellers have depend on charcoal production as a means of livelihood since people have access to wood. Thus, this reliance has negatively impacted on the environment and the health of the producers (Arnold, 2001). In the 1950's forest reservation had reached its peak in most parts of Nigeria especially in the Northern States where approximately 42,000 km^2 were reserved with the addition of an area of over 12,900 km^2 which was proposed for reservation between 1960 and 1972 in the Northern States. In the Southern part of Nigeria, forest reservation had been at a standstill and the prospects of creating more reserves in the future are doubtful. In recent times, most of the forest reserves have been deforested as a result of increase in population and economic expansion in other sectors of the economy. Aside the health consequences of charcoal production, there are also social, health and gender implications

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related to wood fuel consumption (Bailis *et al*., 2001). Shortages of wood fuels for smallholder users are becoming more enormous, especially for the landless poor due to deforestation resulting from large scale charcoal production, as well as reduced access to forests driven by the privatization of resources for both cottage and industrial land users (Bailis *et al*., 2001). These have reduced the livelihood potential for smallholder users dependent on forests. Hence, alternative means to procure products previously gathered from forests are sought through firewood collection activities. This has increased drastically the time spent searching for firewood, thereby preventing women and children from other more productive activities.

Maize is one of the oldest human-domesticated plants. Its origin is believed to date back to at least 7000 years ago when it was grown in the form of a wild grass called *teosinte* in Central Mexico. Recognizing its early potential as a major food crop, over time the *Mesoamerican* natives managed to improve the crop, by systematically selecting certain varieties for their desired traits. This process led to the gradual transformation of *teosinte* to its present day form known as maize, a name which is a likely derivative of "*mahis*", meaning "source of life" for *Tanio* people, the natives known to have mastered its cultivation. Maize is also known as corn, which is the name that has come into common usage primarily because it is used in the United States, the world's largest producer, consumer and exporter of maize.

Colonial conquests and trade played a central role in the spread of maize cultivation well beyond the European continent, to Africa and Far East Asia (FAO, 2016). There exist several hybrids of maize, each with their own specific properties and kernel characteristics; the most common ones include: dent (or field maize, used for livestock feeding and can be yellow or white), flint (or Indian maize, grown in Central and South America), and sweet (or green maize).

Most of the increase in world maize production during the past decade can be attributed to a rapid expansion in Asia (FAO, 2016). Asian maize production grew by nearly 35 percent during the past decade, accounting for almost 30 percent of the global increase (FAO, 2016). Both area and yield increases contributed to this high level of growth, with China making the most significant advance by contributing to as much as 60 percent of the total gains in Asian maize production over the past decade (FAO, 2016). In spite of the advances attributed to the *Green Revolution* and the introduction of high yield maize varieties, the possibilities for maize yield improvements in many countries has remained large as the degree of production efficiency, especially in the developing countries, still falls below major commercial producers. Studies of soil condition using parameters like exchangeable cations ($Ca2^+$, Na^+ and $Mg2^+$), total nitrogen, and others in both charcoal burning sites and adjacent field sites have revealed a significant variation where soil properties are the same indicating that charcoal burning impacts on the soil especially at the kiln site (Oguntunde *et al*., 2008; Ogundele *et al*., 2012; Alexis *et al*., 2007). The relationship between vegetation cover and soil condition has long been established in most parts of the world. Whisenant (2009) diagrammatically illustrated the impact of vegetation loss emanating from land use and the impact on soil condition from short to long term. However, there is a need to investigate on effects of charcoalized on the field performance of maize (*Zea mays*)

Specific objective were to:

To determine the effect of charcoal on the soil colour.

To examine the effect of charcoalized soil on maize seedling height, height at maturity, number of leaves

To determine the growth yield of maize planted with charcoalized soil and the one planted on organic fertilized soil.

2. Methodology

2.1. Study Area

The research was conducted in the Green House of the Science Laboratory Technology in The Oke Ogun Polytechnic, Saki, Oyo state which is located 8.67 latitude and 3.39 longitude and it is situated at elevation 472 meters above sea level. Saki has a population of 178,677 making it the third biggest city in Oyo. It operates on the WAT time zone, which means that it follows the same time zone as Ibadan.

2.2. Sources of Seed collection

Seeds of cultivated maize was collected from the OYSADEP, Saki Oyo State.

2.3. Planting Operation

The treated seeds of maize and cowpea was planted in plastic containers containing 4.2g of charcoal soil in the Green House at the Department of Science Laboratory Technology of The Oke Ogun Polytechnic, Saki Oyo state.

2.4. Data Collection

Data was obtained for stem height, leaf length, and number of leaves; the Nitrogen, Phosphorus, Cadmium, Cobalt, Sodium, Calcium, Iron, Zinc and the pH

2.5. Data Analysis

All the data obtained was analyzed using analysis of Variance and the mean was separated using Duncan's Multiple Range Test (DMRT).

2.6. Stem Height

The stem height of the plant per treatment was determined after two weeks of planting by the height measured in centimeters.

2.7. Number of Leaves per plant

The number of leaf produce per plant was counted and recorded for each treatment after the emergence of the first flower.

2.8. The Leaves' Length

The leaf length was determined per treatment by measuring the leaf produced in centimeter.

2.9. Micro Nutrient in the soil

The nitrogen, potassium, phosphorus content was determined for pre planting and post planting likewise for the control.

3. Discussion

Nutrient uptake by maize like other crops is closely related to dry matter production. This resulted that sites which are consistently high yielding, proportionately higher levels of nutrients are taken up and removed in harvested grain (Belfield & Brown, 2018). In such instances over 50% of the available N and P and approximately 80% of the available K is exhausted before the crop reaches reproductive stage. The rates of N, P and K uptake as well as the cumulative uptake of N, P and K during the growing season are indicated for maize

Table 1 Pre Planting Test Soil Sample used for Planting Maize

Sample	**Nitrogen**	**Phosphorus**	**Potassium**
A with Manure	L_2 (low)	M_2 (medium)	M_2 (medium)
A without Manure	L_1 (low)	M_1 (medium)	M_1 (medium)
B with Manure	L_2 (low)	M_2 (medium)	M_2 (medium)
B without Manure	L_1 (low)	M_1 (medium)	M_1 (medium)
C with Manure	L_2 (low)	M_2 (medium)	M_2 (medium)
C without Manure	L_1 (low)	M_1 (medium)	M_1 (medium)
D with Manure	L_1 (low)	M_1 (medium)	M_1 (medium)
D without Manure	L_1 (low)	L_2 (low)	L_2 (low)
E with Manure	L_1 (low)	M_1 (medium)	M_1 (medium)
E without Manure	L_1 (low)	L_2 (low)	L_2 (low)

Table 2 The Effect of Charcoalized Soil on Maize (*Zea mays*)

Sample	Stem Height	Leaf Length	No of Leaf
A with Manure	22.83	49.33	6.66
A without Manure	12.42	25.83	5.42
B with Manure	25.26	52.59	7.61
B without Manure	8.97	24.52	5.04
C with Manure	23.95	52.73	7.33
C without Manure	13.85	33.61	5.61
D with Manure	37.28	54.85	8.85
D without Manure	14.54	40.10	6.14
E with Manure	40.69	60.14	9.04
E without Manure	18.59	46.33	5.85

The result showed that sample E with manure has the highest Stem height (40.69) while sample E with manure has the lowest value (8.97). It further revealed that the leaf length ranged from 60.14 to 24.52, Sample E with manure has 60.14 while sample B without manure had the 24.52 which is the lowest leaf length among the samples. Number of leaves ranged from 9.04 to 5.42, sample E with manure has the highest values while sample A without manure has the lowest value

Table 3 Showing the Chemical Analysis of posting plating of Maize Sample

Samples	Cadmium (PPM)	Cobalt (PPM)	Sodium (PPM)	Calcium (PPM)	Iron (PPM)	Zinc (PPM)	pH Value
A with Manure	0.00	0.00	0.28	0.53	0.350	0.19	8.2
A without Manure	0.00	0.00	0.5	4.97	0.297	0.25	7.9
B with Manure	0.00	0.00	0.69	2.45	0.0378	0.28	7.8
B without Manure	0.00	0.00	0.007	19.0	0.500	0.82	8.2
C with Manure	0.00	0.00	0.23	0.56	0.419	0.33	7.7
C without Manure	0.00	0.00	0.25	5.02	1.44	0.59	8.0
D with Manure	0.00	0.00	0.27	0.52	4.27	1.69	8.1
D without Manure	0.00	0.00	0.18	0.15	4.91	1.37	
E with Manure	0.00	0.00	0.073	0.02	9.8	0.96	7.8
E without Manure	0.00	0.00	0.120	0.007	13.20	0.67	8.1

Table revealed that there is no significance difference in cadmium and cobalt contents. It further reveled that Sodium ranged from 0.69 to 0.007, Sample B with manure having the highest sodium contents while Sample B without manure having the lowest sodium contents. Calcium ranged from 19.0 to 0.007, Sample B without manure having the highest calcium contents while sample E without manure having the lowest calcium contents among the samples.

Iron ranged from 13.20 to 0.297, Sample E without manure having the highest iron contents while sample A without manure having the lowest iron contents. Zinc ranged from 1.69 to 0.19, Sample D with manure having the highest zinc contents while sample A with manure having the lowest zinc contents.

Table 4 The Chemical Analysis of before plating of Maize Sample

Samples	Cadmium (PPM)	Cobalt (PPM)	Sodium (PPM)	Calcium (PPM)	Iron (PPM)	Zinc (PPM)	pH Value
Sample A	0.00	0.00	0.093	2.24	0.284	0.17	7.7
Sample B	0.00	0.00	0.33	2.22	0.248	0.20	8.2
Sample C	0.00	0.00	0.112	3.92	0.517	0.40	8.3
Sample D	0.00	0.00	0.23	0.62	2.41	0.77	8.0
Sample E	0.00	0.00	0.114	0.003	4.72	0.33	8.2

Table 4 shows that there is no significance difference in cadmium and cobalt contents. Sodium ranged from 0.33 to 0.093, Sample B having the highest sodium contents while sample A having the lowest sodium contents. Calcium ranged from 3.92 to 0.003, Sample C having the highest calcium contents while sample E having the lowest calcium contents. However, Iron content ranged from 4.72 to 0.248, Sample E having the highest iron content while sample C having the lowest iron contents. The pH value ranged from 8.3 to 7.7, Sample C having highest pH value while sample A having the lowest pH value among the samples.

Figure 1 The field performance of maize planted at (a) 3rd week of planting and (b) At maturity after planting in the Green house

4. Conclusion

The charcoal additions proved to sustain fertility if an additional nutrient source is given. Even though significantly more nutrients (P, K, Ca, Mg, and N) were exported from the charcoal plots, the available nutrient contents of the soil did not decrease in comparison to just mineral fertilized plots. The efficiency of biomass conversion into charcoal becomes important in conjunction with a newly proposed opportunity to use charcoal as a soil conditioner that improves soil quality on very acid and highly weathered soils (Lehmann et al. 2002; Steiner et al. 2004). This can be realized either by charring the entire aboveground woody biomass in a shifting cultivation system as an alternative to slash and- burn (coined recently as slash-and-char by (Glaser et al. 2002; Lehmann et al. 2002) or by utilizing crop residues in permanent cropping systems. Charcoal formation during biomass burning is considered one of the few ways that C is transferred to refractory long-term pools (Glaser et al., 2000; Kuhlbusch and Crutzen 1995; Skjemstad 2001). Producing charcoal for soil amelioration instead of burning biomass would result in increased refractory soil organic matter, greater soil fertility and a sink of CO_2 if re-growing vegetation (secondary forest) is used. It is hereby recommended that in other to improved nutrient contents, particularly in C^+, resulted in a significant maize yield increase and further field-testing of charcoalized soil should be continued for three or more growing seasons to see the trends in yield, so as to ascertain the long-term effects of charcoal production on the fertility of tropical soils.

Compliance with ethical standards

Disclosure of conflict of interest

There is no conflict of interest in publishing this article.

References

[1] Alexis, M A, Rasses, D P, Rumpel, C, Bardoux, G, Pechot, N, Schmalzer, P, Drake, B, & Mariotti, A *Fire impact on C and N losses and charcoal production in a scrub oak ecosystem*. Biogeochemistry, 2007; 82:201-216.

[2] Arnold K, *„Poverty Dimensions Of Public Governance and Forest Management in Ghana*', Final Technical Report, DFID Natural Resource Systems Research Programme, Project R7957 Overseas Development Institute, London, and the Institute of African Studies, University of Ghana, Legon. 2001.

[3] Bailis, R. *Modeling Climate Change mitigation from alternative methods of charcoal production in Kenya*. ELSEVIER, Biomass and Bioenergy 2009; 33:1491-1502.

[4] Belfield M, & Brown, E G *Charcoal: Small scale production and use*. Eschborn: Deutsche Gesellschaft fur technische Zusammenarbeit (GTZ). *Markets, states and environmental policy; the political economy of charcoal in Senegal.* In *Energy and Resources*. 2018.

[5] FAO-CLHEE. *Impact of Civil War on Natural Resources: A case study for Somalia land.* Retrieved from http://www.ajol.info 2016.

[6] Ogundele, A T, Eludoyin, O S, & Oladapo O S. *Assessment of impacts of charcoal production on soil properties in the derived savanna, Oyo State, Nigeria*. Journal of Soil Science and Environmental Management 2011; Vol. 2(5), Accessed: (http://www.academicjournals.JSSEM

[7] Ogundele, A T, Oladapo, O S, & Aweto, AO. *Effects of charcoal production on soils in kiln sites in Ibarapa area, South Western Nigeria*. Ethiopian Journal of Environmental Studies and Management EJESM 2012; Vol. 5 No. 3. Retrieved from http://dx.doi.org/10.4314/ejesm.v5i3.12

[8] Oguntunde, P G, Abiodun, B J, Ajayi, A E and van de Giessen, N. *Effects of charcoal production on soil physical properties in Ghana*. Z. Pflanzenernähr. Bodenk. 2008; 171:591–596. doi: 10.1002/jpln.200625185

[9] Kuhlbush, R, A and Crutzen MO *Species accumulation within land use and tree diameter categories in Burkina Faso, Mali, Niger and Senegal*. *Biodiversity and Conservation,* 2008; 17:1883-1905

[10] Skjemstad J Charcoal and other resistant materials. In: Net Ecosystem Exchange Workshop Proceedings, Canberra ACT 2601, Australia, 2001; pp. 116–119

[11] Steiner C, Teixeira WG and Zech W Slash and char: An alternative to slash and burn practiced in the Amazon Basin. In: Glaser B and Woods WI (eds) Amazonian Dark Earths: Explorations in Space and Time. Springer, Heidelberg, 2004; pp. 183–19

[12] Glaser B, Guggenberger G, Haumaier L and Zech W Persistence of soil organic matter in archaeological soils (Terra Preta) of the Brazilian Amazon region. In: Rees RM, Ball BC, Campbell CD and Watson CA (eds) Sustainable Management of Soil Organic Matter. CAB International, Wallingford, CT, 2000; pp. 190–194

[13] Lehmann J, da Silva Jr JP, Rondon M, Cravo MdS, Greenwood J, Nehls T, Steiner C and Glaser B Slash and char – a feasible alternative for soil fertility management in the central Amazon? 17th World Congress of Soil Science, Bangkok, Thailand, 2002; pp. 1–12 422 SN

[14] Mbilinyi, B P, Misana, S, Malimbwi, R E, Monela, G C, & Jambiya, G. *Land cover dynamics as a result of charcoal production: Use of remote sensing and GIS*. Tanzania Journal of forest and nature conservation, 2007; Vol. 76:pp 67-79 Moss, P. Limits of interference by iron, manganese, aluminum and phosphate in the EDTA determination of calcium in the presence of magnesium using cal-red as indicator. J Sci. Fd. Agriculture. 1961; 12: 30-34.

[15] Msuya, N, Enock, M, & Abraham, K T. *Environmental Burden of Charcoal* Production *and Use in Dar es Salaam, Tanzania*. Journal of Environmental Protection, 2011; 2:1364-1369 doi:10.4236/jep.2011.210158. Retrieved from (http://www.SciRP.org/journal/jep)

[16] Muller, N, Michaelowa, A, & Eschman, M. *Proposal for a new standardized baseline for charcoal projects in the clean development mechanism. Perspectives Climate Change.* 2011.

[17] Mugo, F, & Ong, C 2006: *Lessons from eastern Africa's unsustainable charcoal trade*. ICRAF Working Paper no. 20. Nairobi, Kenya. World Agroforestry Centre. Retrieved http://www.worldagroforestry.org/projects/relma/pdfs/Working%20paper%20no%20% 2020%20Lessons%20from%20eastern%20Africa's%20%20charcoal%20trade.pdf

[18] Muzein, B S. *Remote Sensing & GIS for Land Cover/ Land Use Change Detection and Analysis in the Semi-Natural Ecosystems and Agriculture Landscapes of the Central Ethiopian Rift Valley*. PhD Thesis, Technische Universität Dresden Fakultät Forst- Geo- und Hydrowissenschaften Institut für Photogrammetrie und Fernerkundung, Germany. 2006.

[19] Nyame, F K, & Blocher, J. *Influence of land tenure practices on artisanal mining activity in Ghana*. *Resources Policy*, 2010; *35*(1):47-53.

[20] Samuel, N A C. *Integrating Remote Sensing, GIS, Census, and Socioeconomic Data in Studying the Population–Land Use/Cover Nexus in Ghana: A Literature Update*. Africa Development, 2007; Vol. XXXII, No. 2:pp. 197–212 *approach*. Cambridge University press, The Edinburg building, Cambridge CB2 2RU, UK.

[21] Skjemstad J Charcoal and other resistant materials. In: Net Ecosystem Exchange Workshop Proceedings, Canberra ACT 2601, Australia, 2001; pp. 116–119

[22] Steiner C, Teixeira WG and Zech W Slash and char: An alternative to slash and burn practiced in the Amazon Basin. In: Glaser B and Woods WI (eds) Amazonian Dark Earths: Explorations in Space and Time. Springer, Heidelberg, 2004; pp. 183–193