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SOIL PROPERTIES, NUTRITIONAL QUALITY AND YIELD OF TWO MAIZE VARIETIES USING DIFFERENT BIO-CHARS AS AMENDMENT ON METAL CONTAMINATED SOIL

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ABSTRACT

The study assessed the yield of the two maize varieties and also determined the proximate composition of the maize grains and assessed the effects of the Bio-chars on the physical and chemical properties of the soil. The field study was conducted within the vicinity of a metal recycling plant in Ile-Ife believed to have been contaminated with metal particulates and wastewater from the factory. Viable seeds of the two maize varieties (BR-9928-DMR-SR-Y and ART98/SW1) were obtained from the Institute of Agricultural Research and Training (IAR & T), Ibadan. The treatment were made up of the crop with: 100% maize stover (MS), 100% Milicia exelsa (ME), 50% MS + 50% AT, and each at the rate of ten tonnes per hectare as treatments. Zero Bio-char application served as control. The result indicate that the highest mean maize grain yield of 0.43 ± 0.28 t ha^{-1} with 100% maize stover Bio-char application was only significantly ($p < 0.05$) higher than 0.13 ± 0.08t ha^{-1} obtained from control plots. Lower values were obtained with Br-9928-DMR-SR-R. Highest protein (9.94 ± 0.71%), crude fibre (2.60 ± 0.26%) and vitamin C (24.23 ± 2.26 mg kg^{-1}) were obtained for the harvested ART 98 SW1 when compared with Br-9928-DMR-SR-Y. Addition of Bio-chars soil enhanced the soil organic carbon, nitrogen, available phosphorus and cation exchangeable capacity. The study concluded that the use of maize stover and M. exelsa Bio-chars at 10 t ha^{-1} as soil amendments enhanced the physiological performance, yields and proximate compositions of maize. It also enhanced the physical and chemical properties of the Bio-char amended metal contaminated soil.

Keywords: Amendment, Bio-char, Contamination, soil properties, environment, maize, proximate composition, pollution

INTRODUCTION

The Investigations on the effects of Bio-char on soil, crop yield and environment are being undertaken worldwide. However, the results are not uniform. A logically organized complete study of the effects of Bio-char from different feed stocks on different crops, their interaction with micro-organisms and agriculturally important heavy metals such as Zinc (Zn),Cadmium (Cd) and Copper (Cu) could confirm to what extent Bio-char is beneficial to croplands. This section therefore evaluates Bio-char effects on crop yield, soil fertility and heavy metal immobilization and the interactive effects of Bio-char on crops and soil nutrients as well as the physical and chemical properties of the soil.

Although the compositions of Bio-chars depend upon the nature of the feedstock and the operating conditions of pyrolysis, Bio-chars are generally expected to be rich in nutrients. These characteristics can have a direct effect on the plant growth. For example, improved crop yields have been attributed to improvement in phosphorous (P), potassium (K) and possibly copper (Cu) levels following the addition of Bio-char (Chan and Xu, 2009). Bio-char has the potential to increase cation exchange, soil water-holding and surface sorption capacity on account of the physical and chemical characteristics of Bio-char; specifically; its high surface-area, high porosity and variable-charge (Amonette and Joseph, 2009; Yang *et al.*, 2010).

Therefore, the application of Bio-char is expected to enhance soil properties in terms of increasing or maintaining the pH of the soils (Rondon *et al.*, 2007), toxin neutralization (Wardle *et al.*, 1998), and increase soil strength (Chan *et al.*, 2007).

European Commission (Verhaijen *et al*., 2010) defined Bio-char as:"charcoal (biomass that has been pyrolyzed in a zero or low oxygen environment) for which, owing to its inherent properties, scientific consensus exists that application to soil at a specific site is expected to sustainably sequester carbon and concurrently improve soil functions (under current and future management), while avoiding short- and long-term detrimental effects to the wider environment as well as human and animal health."

Bio-char holds the potential to reduce atmospheric CO_2 concentrations by sequestering carbon from the atmosphere, into biomass, and 'locking-up' this carbon when this biomass is converted into Bio-char. Bio-char is recalcitrant and physically stable; to the extent that, once applied to soil, it becomes a persistent component within the soil matrix.

The response of agricultural crops to various application levels and different Bio-chars is vital for devising applicable strategies which are suitable for long term carbon sequestration in sustainable farming. According to Atkinson *et al*. (2010) the significance attached to the level at which Bio-char application may increase agricultural production is a key driver in any attempt to develop systems that economically incorporate pyrolysis products within the soil. Asia *et al*. (2009) studied the effects of Bio-char application on rice yields (*Oryza sativa* L.) and selected plant traits.

Bio-char is normally of alkaline pH and may change soil pH in a favourable trend for most crops (Chan and Xu, 2009). The ash content of Bio-char is principally accountable for the modification of the soils pH. Steiner *et al*., (2008) established that Bio-char can operate as an absorber lowering N leaching and increasing N use efficiency. Nitrogen use efficiency is of great importance, especially to sustain future population growth.

Bio-char addition to soils can stimulate microorganism activity in the soil, potentially affecting the soil microbiological properties (Hammes and Schmidt 2009). Relatively supplying microorganisms with a prime source of nutrients, Bio-char is considered to improve chemical and physical environment in soils to provide microbes with a further favourable habitat (Krull *et al*., 2010). The field experiment was aimed at determining the chemical properties of the Bio-chars; and also to assess the physiological performance of the two maize varieties.

MATERIALS AND METHODS

Study Area

The field study was conducted within the vicinity of a metal recycling plant in Ile-Ife believed to have been contaminated with metal particulates and wastewater from the factory. The site was cleared twice of all debris and weeds using cutlass around July in the year 2015. Viable seeds of the test crop comprise of two maize varieties (BR-9928-DMR-SR-Y and ART98/SW1) were obtained from the Institute of Agricultural Research and Training (IAR & T), Ibadan, Nigeria.

Experimental Design/Data Collection

The experimental plot size was 11·0 m×15·0 m which was in turn divided into four equal block sizes of 11·0 m×3·0 m with an alley of 1·0 m between blocks and within blocks. Each of the blocks was then divided into four equal subplots, each measuring 2 m ×3 m to give a total of 16 subplots in each experimental site. The test crop was sown at three seeds per hill using 75 cm × 50 cm planting distance. In all, there were four treatments, each was replicated four times and laid out in a Randomized Complete Block Design (RCBD). The treatments were 100% maize stover, 100% African teak, 50% maize stover + 50% African teak and Zero Bio-char application to serve as control. Maize ears were harvested per treatment at maturity, processed and the dry weight was determined per treatment. Soil samples were air-dried for five days, grounded and sieved using a 2 mm mesh sieve prior to for analyses.

Data Analysis

For texture; (Bouyoucus hydrometer method), pH; (1:1 soil-1M Kcl suspension), and Nitrogen; (Macro-Kjeldahl method), Phosphorus; (Murphy and Riley method), Organic carbon; (Walkley and Black method), exchangeable acidity; (Mclean and USDA), and the selected metals; (Mn, Fe, Cu and Zn) were analysed by Atomic Absorption Spectrophotometer (AAS) while the proximate compositions were determined by routine chemical method of analytical method of association official analytical chemists (A.O.A.C., 2003).

RESULTS

The physical and chemical properties of the soil used in the study are shown in Table 1. The soil had 116.00g kg-^{1} clay, 754.00g kg-^{1} sand and 130.00g kg-^{1}silt, thus the soil was loamy sand in texture. The soil pH in 1:1 soil to water suspension was 5.30 indicating a slightly acidic condition. The soil organic carbon was 0.94 g kg-^{1}, the total nitrogen of the soil was 0.10 g kg^{-1} while the available phosphorous was 4.45 mg g-^{1}. The cation exchange capacity (CEC) (Ca^{2+}, Mg^{2+}, K^{+} and Na^{+}) of the soil was 8.30 cmol kg$^{-1;}$ exchangeable acidity was 0.40 cmol kg-1.

Table 1: physical and chemical properties of the pre-cropped soil

Property	Value
pH (1:1 soil/water)	5.30
Organic carbon (g kg^{-1})	0.94
Nitrogen (g kg^{-1})	0.10
Available phosphorous (mg g^{-1})	4.45
Exchangeable acidity (cmol kg-^{1})	4.00
H^{+}	0.40
Al^{+++}	0.00
Exchangeable Basicity (cmol kg^{-1})	8.30
Ca^{2+}	5.94
Mg^{2+}	1.46
K^{+}	0.15
Na^{+}	0.75
ECEC (cmol kg^{-1})	15.12
Clay (g kg-^{1})	116.00
Silt (g kg-^{1})	130.00
Sand (g kg-^{1})	754.00
Textural class	Loamy sand

The proximate composition of the two maize varieties is presented in table 2. The values ranged from 8.87 – 9.22 % for protein, 3.90 – 4.20 % for fat, 2.30 – 2.50 % for crude fibre, 2.10 -2.40 % for total ash, 92.15 – 92.44 % for dry matter, 81.48 – 82.52 % for carbohydrate, 6.1 – 11.10 % for reducing sugar, 52.74 – 62.91 % for total sugar and 16.62 – 33.11 mg kg^{-1} for Ascorbic acid.

Table 2: The proximate compositions of the two maize varieties

Composition	A	B
Protein (%)	9.94 ± 0.71	9.27 ± 0.25
Ash (%)	2.23 ± 0.13	2.27 ± 0.88
Fat (%)	4.26 ± 0.88	4.10 ± 0.10
Crude fibre (%)	2.60 ± 0.26	2.43 ± 0.67
Dry matter (%)	92.33 ± 0.43	92.29 ± 0.84
CHO (%)	81.59 ± 0.67	81.93 ± 0.39
Reducing sugar (%)	5.23 ± 1.24	7.67 ± 1.72
Total sugar (%)	63.26 ± 0.40	59.03 ± 3.17
Ascorbic acid (mg kg^{-1})	24.23 ± 2.26	24.19 ± 4.81

The mean and the standard error for the proximate composition of maize variety ART 98/SW1 is presented in Table 3. Maize variety ART 98/SW1 with treatment A (100% maize stover) had the highest weight (0.43 ± 0.28 t ha^{-1}). The lowest weight of (0.13 ± 0.08 t ha^{-1}) was recorded in the same variety in the control plant (C). Treatment B (100% *Milicia exelsa*) and treatment AB (50% maize stover + 50% African teak) had very close weights of (0.36 ± 0.32 t ha^{-1}) and (0.37 ± 0.23 t ha^{-1}) respectively. In the same vein, for maize variety Br-9928-DMR-SR-Y, treatment B (100% *Milicia exelsa*) was observed to have the highest weight of (0.39 ± 0.24 t ha^{-1}) while the control plant had the lowest weight of (0.23 ± 0.14 t ha^{-1}). Plant treated with AB (50 % maize stover + 50% *Milicia exelsa*) was also noted to have the weight of (0.38 ± 0.23 t ha^{-1}) which was a bit higher than plant with treatment A (100% maize stover) with the weight of (0.33 ± 0.20 t ha^{-1}) all at the same application rate of 10 t ha^{-1}.

Table 3: Proximate Composition of the Two Maize Varieties

Treatment	ART 98/SW1	Br-9928-DMR-SR-Y
A	0.43 ± 0.28^{a}	0.33 ± 0.20^{a}
B	0.36 ± 0.32^{a}	0.39 ± 0.24^{a}
AB	0.37 ± 0.23^{a}	0.38 ± 0.23^{a}
C	0.13 ± 0.08^{b}	0.23 ± 0.14^{b}

Mean with the same letters in each column are not significantly different by Bonferroni Multiple Comparison Test at p < 0.05
Legend: A = 100% maize stover; B = 100% *Milicia exelsa*; AB = maize stover 50% + 50% *Milicia exelsa*; C = Control.

The Organic carbon, nitrogen and phosphorous concentrations in the soil after harvest of the maize are presented in Table 4. Values for Oc ranged from 0.94 – 18.82 g kg^{-1}, for the first site cultivated with variety ART 98/SW1, while for variety Br-9928-DMR-SR-Y ranged from 0.98 – 19.94 g kg^{-1},Soils with treatment AB (50% maize stover + 50% *Milicia exelsa*) had highest values and the least values were recorded in the control of the two varieties respectively. Nitrogen values ranged 0.10 - 0.43 g kg^{-1}for ART 98/SW1 and 0.09 – 0.41 g kg^{-1} for the second variety. Soils with treatment B (100% African teak) had the highest value in ART and treatment AB (50% maize stover + 50% *Milicia exelsa*) in the other variety while both control had lowest values. Phosphorous concentration in the soil also ranged from 4.45 - 17.99 mg g^{-1} in ART and 4.41 - 14.61 mg g^{-1} in the Br-DMR-SR–Y. Soils with treatment B had the highest value in ART and treatment A (100% maize stover) had the highest value in the other variety while the controls of the two varieties had the lowest value respectively.

Table 4: Organic Carbon, Nitrogen and Phosphorous Concentrations in the Soil after Harvest

Treatment ART98/SW1	**OC**	**N**	**P**
A	14.90^{a}	0.41^{a}	13.76^{ab}
B	7.88^{b}	0.43^{a}	17.99^{a}
AB	18.82^{a}	0.39^{a}	17.35^{a}
C	0.94^{c}	0.10^{b}	4.45^{b}
Br-9928-DMR-SR-Y			
A	13.70^{a}	0.38^{a}	14.61^{a}
B	8.64^{b}	0.37^{a}	8.87^{b}
AB	19.94^{a}	0.41^{a}	11.00^{a}
C	0.98^{c}	0.09^{b}	4.41^{c}

Mean with the same letters in each column are not significantly different by Duncan’s Multiple Range Test at p < 0.05
Legend: A = 100% maize stover; B = 100% *Milicia exelsa*; AB = maize stover 50% + 50% *Milicia exelsa*; C = Control.

The pH values and exchangeable acids (H^+ and Al^{3+}) concentrations in the soil after harvest of the maize are presented in Table 5. pH values ranged from 4.87 – 5.47 and treatment A (100% maize stover) had the highest value while the treatment AB (50% maize stover + 50% *Milicia exelsa*) had the lowest value in the variety ART 98/SW1, but in the variety Br 9928-DMR-SR-Y, the pH values ranged from 5.31 – 6.94, the control had the lowest value while treatment A (100% maize stover) had the highest. The concentrations of H^+ and Al^{3+}in the soil made up the exchangeable acids. $Al^{3+}$was not detected in the post-soil test. Therefore, H^+Values ranged from 0.40 – 0.70cmol kg^{-1} with the treatment AB (50% maize stover + 50% *Milicia exelsa*) having the highest value and the control the lowest the value in variety ART 98/SW1. The H^+ concentration in the soil cultivated with maize variety Br-9928-DMR-SR-Y also ranged from 0.40 – 0.90 cmol kg^{-1}, treatment B (50% *Milicia exelsa*) had the highest value while the control had lowest value.

Table 5: Soil pH and Exchangeable Acidity H^+ and Al^{3+} in Soil after Harvest

Treatment	**pH**	**H^+**	**Al^{+++}**
ART98/SW1			
A	5.47^a	0.60^{ab}	0.00^a
B	5.37^a	0.60^{ab}	0.00^a
AB	4.87^a	0.70^a	0.00^a
C	5.31^a	0.40^b	0.00^a
Br-9928-DMR-SR-Y			
A	6.94^a	0.44^b	0.00^a
B	6.67^a	0.90^a	0.00^a
AB	6.68^a	0.50^b	0.00^a
C	5.31^b	0.40^b	0.00^a

Mean with the same letters in each column are not significantly different by Duncan's Multiple Range Test at $p < 0.05$

Legend: A = 100% maize stover; B = 100% *Milicia exelsa*; AB = maize stover 50% + 50% *Milicia exelsa*; C = Control.

Calcium, magnesium, potassium and sodium concentrations in the soil after harvest of the maize are presented in Table 4.7. Values for calcium ranged from 5.93 – 10.85 cmol kg^{-1}, magnesium from 1.45 – 3.04 cmol kg^{-1} and potassium had values ranged from 0.14 – 0.39 cmol kg^{-1}. Soils with treatment A (100% maize stover) had the highest values while the control had the least values in the three in them except for in sodium where the treatment B (100% *Milicia exelsa*) ranged between 0.57 – 0.83 cmol kg^{-1} had the highest value and the control the lowest, All this were recorded for the maize variety ART 98/SW1.

In the second variety Br-9928-DMR-SR-Y, the values for calcium ranged from 5.93 – 19.01 cmol kg^{-1}, magnesium from 1.45 – 3.18 cmol kg^{-1} with the highest values in the soils with treatment AB (50% maize stover + 50% *Milicia exelsa*) and the least values were recorded in the controls. While value for potassium ranged from 0.14 – 0.34 cmol kg-^{1} and for sodium ranged from 0.72 – 0.78 cmol kg-^{1} with the highest value in soils with treatment A (100% maize stover) while lowest was in the control and treatment AB (50% maize stover + 50% *Milicia exelsa*) in the case of potassium and sodium respectively.

Table 6: Calcium, Mg, Na and CEC (cmol kg^{-1}) of the soil after harvest

Treatment ART98/SW1	Ca	Mg	K	Na	ECEC
A	10.85^{a}	3.04^{a}	0.39^{a}	0.74^{a}	15.63^{a}
B	8.95^{a}	2.82^{a}	0.37^{a}	0.83^{a}	13.49^{a}
AB	7.04^{a}	2.66^{a}	0.25^{ab}	0.72^{a}	12.25^{a}
C	5.93^{b}	1.45^{b}	0.14^{b}	0.57^{a}	15.10^{a}
Br-9928-DMR-SR-Y					
A	7.77^{b}	2.75^{a}	0.34^{a}	0.78^{a}	12.28^{a}
B	7.58^{b}	2.62^{a}	0.25^{a}	0.78^{a}	12.15^{a}
AB	19.01^{a}	3.18^{a}	0.27^{a}	0.72^{a}	18.68^{a}
C	5.93^{b}	1.45^{b}	0.14^{b}	0.75^{a}	15.11^{a}

Mean with the same letters in each column are not significantly different by Duncan's Multiple Range Test

Legend: **A**= 100% maize stover; **B** = 100% *Milicia exelsa*; **AB** = maize stover 50% + 50% *Milicia exelsa*; **C** = Control.

The concentrations of manganese, iron, copper and zinc in the soils after harvest for the two maize varieties are presented in Table 7. The value of manganese for the first variety ART 98/SW1 ranged from 57.85 – 109.60 mg g^{-1} and the highest was in the soil with treatment AB (50% maize stover + 50% *Milicia exelsa*) and the control with the lowest value, concentration of iron also ranged from 82.85 – 133.80 mg g^{-1} with the control having the least value. The concentration of copper was in the range of 4.44 – 9.80 mg g^{-1}, with the highest value in the control and the lowest in the treatment AB (50% maize stover + 50% *Milicia exelsa*) while zinc concentration ranged from 112.60 – 787.30 mg g^{-1} with the highest value in the treatment B (100% *Milicia exelsa*) and the lowest in the treatment AB (50% maize stover + 50% *Milicia exelsa*).

Meanwhile in the second variety Br-9928-DMR-SR-Y, the value of manganese ranged from 55.80 – 125.50 mg g^{-1} and the highest was in the soil with treatment B (100% *Milicia exelsa*) and the control with the lowest value, concentration of iron in the soil also ranged from 82.85 – 123.80 mg g^{-1} with the control having the least value as in the case of manganese. Copper concentration was in the range of 3.70 – 9.90 mg g^{-1}, with the highest value in the control and the lowest in the treatment AB (50% maize stover + 50% *Milicia exelsa*) while zinc concentration ranged from 84.00 – 337.80 mg g^{-1} with the highest value in the control B and the lowest in the treatment B (100% *Milicia exelsa*).

Table 7: Mn, Fe, Cu and Zn concentrations (mg g^{-1}) in the soil after harvest

Treatment ART 98/SW1	Mn	Fe	Cu	Zn
A	109.10^{a}	82.85^{c}	7.35^{a}	163.10^{b}
B	104.30^{a}	88.75^{c}	11.20^{a}	457.30^{a}
AB	109.60^{a}	102.10^{b}	4.44^{b}	112.60^{b}
C	57.85^{b}	133.80^{a}	9.80^{a}	787.80^{a}
Treatment ART 98/SW1				
A	109.00^{a}	86.75^{ab}	9.70^{a}	286.50^{a}
	125.50^{a}	73.80^{b}	3.70^{b}	84.00^{c}
	106.00^{a}	86.00^{ab}	6.75^{a}	118.50^{b}
	55.80^{b}	123.80^{a}	9.90^{a}	337.8^{a}

Mean with the same letters in each column are not significantly different by Duncan's Multiple Range Test at $p < 0.05$

Legend: A = 100% maize stover; B = 100% *Milicia exelsa*; AB = maize stover 50% + 50% *Milicia exelsa*; C = Control

DISCUSION

Bio-chars had positive influence on the yield of the two maize varieties compared to the control plant, (Table 3). This was in agreement with results of Rachael, (2008) that there was an improvement in the yield of corn when Bio-char was used as soil amendment. Plant with treatment A (Maize stover) had the highest mean yield for the variety ART 98/SW1 followed by treatment AB (AB 50% maize stover + 50% *Milicia exelsa*) for the second variety Br-9928-DMR-SR-Y which showed improved growth performance and yield when compared to the controls of the two maize varieties where lowest mean yields were recorded. This result was in line with the results of Ndor *et al*., (2015) who worked on response of maize varieties to Bio-char amended soil in Lafia, Nigeria, and found out that application of Bio-char at 10 t ha $^{-1}$ produced the highest yield of maize grain; and also conformed to the work of Rondon *et al.*, (2010), who worked on maize yield and nutrition with Bio-char application. This showed that application of Bio-char as soil amendment positively influenced the yield of the maize.

The mean of the proximate composition of the two maize varieties are presented in Table 2 and 3, the carbohydrates and total sugar were very high when compared to the reducing sugar in the two maize varieties, the dry matter was also high while the protein, fat and crude fibre were low when compared with the values obtained in the carbohydrates and total sugar in the two maize varieties, this was in agreement with the findings of Ijagbadeniyi and Adebolu (2005), who worked on the proximate composition of some maize grown in Nigeria using the same routine chemical analytical methods of Association of official analytical chemists (A.O.A.C, 2003).The results indicated that grains of the maize varieties vary greatly in term of protein, fats and crude fibre contents. The variability observed in carbohydrates, protein, fats, ash content, crude fibre and moisture content could be both genetic and environmental due to the individual chemical composition and weight distribution of the endosperm. Maize variety ART 98/SW1 had the high protein content compared to the variety (Br-9928-DMR-SR-Y).

Application of Bio-char as soil amendment had a significant influence on the yield of maize and improved the properties of the soil. It had a significant improvement on the organic carbon, nitrogen and phosphorus contents of the soil compared to the control, this is due to the fact that the Bio-char used in this study contain more organic carbon, phosphorous and ash (Table 4.), this agreed with the findings of Kookana *et al*., (2011). Mohammed *et al*., (2014) also noted that the mineralization rate of carbon in a Bio-char amended soils was very low, thus making it a better option for carbon sequestration due to its slow carbon mineralization. The pH of the two Bio-char was alkaline while that of the of the soil was slightly acidic (Table 5.), the addition of Bio-char could only bring slight changes in the pH and increase the mobility of the cations in the soil due to reduced competition between H^+ and metals for cation exchange sites either directly on the surface of the Bio-char or as a general liming effect on the soil matrix. In addition, the values for Al^{+++} in the soil were zero throughout all the treatments because the Aluminium hydroxide in the soil had turned to Aluminium sulphate which is an indication of leaching being going on in the soil especially nitrogen due to the low pH. Meanwhile the Bio-char application to the soil had significant impact the calcium, sodium, magnessium and effective cation exchange capacity (ECEC) of the soils across all the treatment, because the values were high across the treatments when compared to their concentration in the pre-cropping analysis except in the control (Table 6.). When Bio-char is incorporated into the soil it reduces the size pores thereby increases the water holding capacity of the soil and providing a medium for adsorption. Also it had been reported that long-term application of Bio-char may increase the levels of phosphorous and potassium in the soil (Dam *et al*., 2005).

The concentrations of the metals (iron, zinc and copper) in the soil were very high since the bioavailability of metals in the soil is pH dependent and differences were noticeable in the controls while the concentrations in all other treatments with amendment were low because the Bio-chars were able to form complex metal ions on their surface and therefore increased the bioavailability of the metals because of the moderately acidic nature of the soil Table 7. So with the application of Bio-char the metal was more available on the soil matrix.

CONCLUSION

This research had revealed that the Bio-char used as soil amendment improved the yield of the maize grown on a metal contaminated soil. The Bio-char used in the study of maize stover and *Milicia excelsa* were able to act as a chelating agent in the soil thereby preventing the metals from getting infiltrated into the subsoil, reduces the sizes of the soil pores thus increases the water holding capacity of the soil, buffer the acidic nature of the soil, increasing the CEC of the soil and providing medium for adsorption of minimal plant nutrients. The amendment had visible impact on the yield though not significant. The results revealed that the Bio-chars as soil amendment improved the soil properties and as well influence the nutritional quality of the maize. From the results presented, the combination of the maize stover and *Milicia excelsa* (AB) treatment appears to be the best.

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