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Effect of Daniella olivera wood biochar on the growth and biomass of maize (*zea mays* L.) in Lafia, North central Nigeria

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The study aimed to evaluate the effect of Daniella wood Biochar on the growth and biomass of maize harvested 8 weeks after sowing in a pot experiment. The research was carried out in order to evaluate the effect of Daniella wood biochar on the growth and biomass of maize and the effects of Daniella wood biochar on the physiochemical properties of the soil. Pots were filled with 5 kg of normal soil (oxisol) and biochar was thoroughly mixed with the soil and six treatments were applied (4, 8, 12. 16 and 20 tha^{-1} of biochar and control). The treatments were replicated three times. The experiments were laid out in a complete randomized design (CRD). Data on growth parameters such as plant height, number of leaves, leaf area, stem diameter, fresh leaf weight, dry leaf weight, fresh shoot weight, dry shoot weight, fresh biomass weight and dry biomass weight were collected. Soil samples incorporated with daniella wood biochar were collected before planting and after harvest for determination of physiochemical properties of the samples. Application of 12 tha-^{1} produced significantly (P<0.01) higher plant height (142.2 cm) wider Leaf area (538.0 cm^{2}), higher fresh biomass weight (221.4 gpot^{-1}), dry biomass weight (79.9 gpot^{-1}), fresh shoot weight (140.0 g), dry shoot weight (53.7 gpot^{-1}), fresh leaf weight (81.4 gpot^{-1}) and dry leaf weight (32.5 gpot^{-1}) while 20 tha^{-1}produced highly significant number of leaves (17) and wider stem diameter (1.63 cm). In conclusion, it was established that the application of 12tha^{-} Daniella wood biochar generally increases maize growth parameters (plant height, leaf area, fresh leaf weight, dry leaf weight, fresh shoot weight, dry shoot weight and plant biomass weight), while 20 tha^{-1} increases the leaf production and stem diameter of the crop.

Key words: Biochar, maize, growth, biomass and oxisols.

INTRODUCTION

Maize (*Zea mays* L.) belongs to the family poaceae, sub family panicoideae, and tribe, Andropogoneae. It is a coarse robust cereal crop, attaining a height of about 1-6 m depending on the variety (Sharma, 2010). Maize is grown between latitude 58^{0} north and 40^{0} south of the equator and requires an annual rainfall of 600-900 mm IITA, 2006); sandy loam and silt loam soils containing adequate organic matter and tolerates soil pH from 5.5 to

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(8.0 but the optimum range is 5.5-7.0.

Ideal temperature for maize growth ranges between 21-27°C (Wolkowski, 2001). Maize was relatively a minor food crop in Africa by 1900 (Manyong et al., 2003), but over the years its widespread uses in human diet and animal feeds popularize it in Africa, especially in Nigeria. Maize was the most widely adapted and the most important cereal in the world in 2009 with a production of 822.7 million metric tonnes followed by rice and wheat with 782.3 and 680.2 million metric tonnes respectively (FAO, 2012). United States of America is the largest producer accounting for 37.2% of the world's total, followed by China and Brazil that accounted for 20.1 and 7.1% respectively (FAO, 2012). Africa produces 6.7% of the world's total from 29.3 million hectares. Nigeria is the second largest producer in Africa with 9.41 million metric tonnes which represent 0.9% of the world's total figure (FAO, 2012). However, like every other crop, maize production requires some agronomic practices most especially soil nutrient amendments such as biochar to improve its productivity and biomass quality. Biochar is a stable form of charcoal produced from heating natural organic materials (crop biomass, wood chips, and other agricultural waste) in a temperature below 1000°C and low oxygen; the process is known as pyrolysis (Lehmann et al., 2006b). The addition of biochar as an amendment material to agricultural soil is receiving much attention due to the apparent benefits of biochar to soil quality and enhanced crop yields, as well as the potential to gain credits by active carbon sequestration.

The addition of Biochar to soils is an ancient practice that has only recently attracted the attention of scientists and is strongly promoted by many as a way to sequester carbon while improving soil properties. The addition of Biochar as amendment materials to degraded soils is receiving a global attention due to the apparent benefits of biochar to soil quality and enhancement of crop yields, as well as the potential of biohar to actively sequestered carbon (Major, 2011). An understanding of the chemical changes that occur in biochar amended soils is a key in managing agricultural soils. This is particularly of importance because the application of biochar to soil as an amendment has shown some physical and chemical advantages. Before considering the influence of biochar on macro-nutrient release, the nutrient content in biochar must be considered first. The addition of biochar to forest soils has been found to directly influence nitrogen transformations in phenol-rich acidic forest soils of temperate and arboreal forest ecosystems (Deluca and Sala, 2006). Also applying biochar to forest soils along with natural or synthetic fertilizers has been found to increase the bioavailability and plant uptake of phosphorus, alkaline metals and some trace metals (Glaser et al., 2002).

The benefits of biochar includes soil nutrients improvement and cation exchange capacity, decreased soil acidity, improved soil structure, nutrient use efficiency, improved water holding capacity and carbon sequestration. Maize has been of great importance in providing food for man, feed for livestock and raw materials for some agro-based industries. Maize consists of 71% starch, 9% protein and 4% oil on a dry weight basis (FAO and ILO, 1997). Despite the importance of maize to the teeming population of Nigerians, its production has not met the food and industrial requirement of the country (Iken and Amusa, 2004). This may be attributed to soil deterioration from depletion of organic matter which is a serious global problem. When the soil is intensively cultivated with high levels of chemical fertilization, the organic matter in the soil microbes and this gas are released into the atmosphere, leaving the soil compacted and nutrient-poor as well as adding to global warming (Ndor et al., 2010). One feasible measure to increase soil fertility is addition of biochar (Verheijen et al., 2010). There are a number of experiments conducted to examine the yield of maize with biochar amended soils. In most of these studies, biochar application increased crop yields of maize over the control between 2.2 tha^{-1}(Van Zwietan et al., 2010, Sukartono et al., 2011; Islami et al., 2011). Other studies found increases in maize yield due to biochar amendment ranging from 20 to 140% above control plots (Crane-Droesch et al., 2012; Major et al., 2010; Oguntunde et al., 2004). Therefore, the objective of the study was to evaluate the effect of Daniella wood biochar on the growth and biomass of maize and evaluate the effects of Daniella wood biochar on the physio-chemical properties of soil.

MATERIALS AND METHODS

Experimental site

The experiment was conducted in the greenhouse of Faculty of Agriculture Shabu-Lafia Campus, Nasarawa State University Keffi during the 2016 dry season, (Latitude 08^{0}33N and Longitude), (Jayeoba, 2013). The area is characterised by a sub-humid tropical climate with wet and dry season; it has an annual rainfall distribution of about 113 mm and mean annual temperature of 27°C; minimum and maximum temperature of 24.80 and 33°C, respectively.

Biochar preparation

Biochar from Daniella softwood from secondary forest were prepared by pyrolysis method as described by Major et al. (2010) using a local earth mould kiln technology (clay oven). The woods were cut and sundried to reach water content of about 17% and then heated in the locally made clay oven. Pyrolysis time was seven days after removing the Daniella wood biochar; the temperature of the produced biochar, when coming out of the process is over 600°C requiring cooling in an air-tight pit. After cooling, biochar was crushed into coarse powder. Then 5 kg soil sample obtained from the experimental site was filled in each plastic pot and biochar was thoroughly mixed with the soil.

Treatment and experimental design

The experimental design used was complete randomized design

(CRD) consisting of six biochar rates (0, 4, 8, 12, 16 and 20 (tha^{-1}) replicated three times. Four seeds, obtained from the Nasarawa Agricultural development programme Lafia, were sown in pots and later thinned to two seedlings per pot after germination.

Soil sample collection

Top soil was collected at a depth of 0-15 cm with soil auger from the teaching and research farm of the faculty of Agriculture Shabu-Lafia campus Nasarawa State University Keffi, for screenhouse pot experiment. Then 5 kg of the soil obtained was filled into 6 plastic buckets which is equal to the number of treatment and replicated three times to produce 18 plastic buckets.

Laboratory analysis of biochar amended soil

All soil samples (soil sample before sowing the seeds and soil sample after harvest) collected were air-dried, gently crushed then passed through 2 mm sieve to obtain a homogeneous particle size. Later both the physical and chemical properties of these samples were determined.

Data collection

Data were collected on plant height (cm), number leaves per plant, leaf area (cm^2), stem diameter (cm), fresh shoot weight, dry shoot weight, fresh leaf weight, dry leaf weight and plant biomass weights (gpot^{-1}).

Data analysis

The data collected were subjected to analysis of variance using GENSTAT (2008). Separation of treatment means for significant effects was done using the least significant difference (LSD) at 5% alpha level.

RESULTS

Physical and chemical properties of the biochar amended soil before sowing

Physical and chemical properties of the biochar amended soil before sowing (Table 1) shows the effect of Daniella wood biochar on the soil physical and chemical properties before sowing during the 2016 dry season. The result revealed that application of 20 tha^{-1} has the highest organic carbon (1.99%), organic matter (1.73%), magnesium (1.59 cmolkg^{-1}) while pH in distilled water was (6.60%) and in acid solution (5.88%) respectively. However, 4tha^{-1} has the highest nitrogen (0.085%) while the highest available phosphorus of (3.7 gkg^{-1}) was obtained in 8 tha^{-1}. Similarly, the highest potassium, sodium, and cation exchange capacity was obtained in control with the values (0.28, 0.60, and 6.89 cmolkg^{-1}).

Physical and chemical properties of biochar amended soil after harvest

Physical and chemical properties of biochar amended soil after harvest. Table 2 shows the effect of Daniela wood biochar on the soil physical and chemical properties after harvest during the 2016 dry season. The results revealed that 8 tha^{-1} had the highest pH value in distilled water (6.70%) while 8 and 16 tha^{-1} had the highest pH value in acid solution (5.98%). 8tha^{-1} has the highest organic carbon and organic matter values (0.96 and 1.68%) respectively. However, 16tha^{-1} has the highest total nitrogen and available phosphorus of 0.09 and 4.1 gkg^{-1}respectively. 8tha^{-1} had the highest calcium magnesium, potassium, sodium and cation exchange capacity values of 3.92, 1.78, 0.35, 0.68 and 7.40, respectively.

Effect of Daniella wood biochar on plant height of maize

There was a significant difference in Daniella wood biochar rates in all sampling period except at 4 weeks after sowing. At 2, 3, 5 and 6 weeks after sowing, 4 tha^{-1} of Daniella wood biochar produced the plant with the highest height compared with other rates. While at 7 and 8 weeks after sowing, application of 12 tha^{-1} of Daneilla wood biochar produced plants with significantly higher height values of (122.8 and 142.2 cm) while the lowest values (76.7 and 81.0 cm) were obtained in control plots (Table 3).

Effect of Daniella wood biochar on number of leaves per plant of Maize

A significant difference on the number of leaves per plant was recorded at 2,4,6,7 and 8 weeks after sowing, where at 2 weeks after sowing application of 4tha^{-1}, 12tha^{-1} and control produced similar number of leaves but more than other rates; at 4 weeks after sowing, 4, 8, 12,16, and 20 tha^{-1} rates also produced similar number of leaves but were significantly better than control rates. At 6 weeks after sowing 8, 12, and 20 tha^{-1} higher number of leaves compared to other rates. At 7 weeks after sowing 20 tha^{-1} produced the highest number of leaves compared to other rates. While at 8 weeks after sowing 12 and 20 tha^{-1} produced significantly more leaves (17.33) when compared to other Daniella wood biochar rates (Table 4).

Effect of Daniella wood biochar on Leaf area of Maize

There was a significant increase in leaf area among Daniella wood biochar rates at all sampling periods except at 4 weeks after sowing were there was no significant difference between rates. Application of 12 tha^{-1} of Daniella wood biochar produced significantly ($P<0.002$) the widest leaf area of (538.0 cm^2) (Table 5).

Effect of Daniella wood biochar on stem diameter of maize

A significant difference was recorded among Daniella

Table 1. Initial routine physiochemical analyses of biochar amended soil.

S/N	Treatment DWB (tha^{-1})	Particle size % Sand	Distribution % Silt	% Clay	Textural class	pH H_2O 1:1	Kcl 1:1	Org.c %	Org.m %	N %	Available P mg/kg	Ca	Exchangeable cations Mg (cmol/kg)	K	Na	CEC
1	0	83.0	9.1	7.9	Loamy sand	5.88	5.05	0.60	1.04	0.056	3.0	3.63	1.50	0.28	0.65	6.89
2	4	82.7	10.2	7.1	Loamy sand	6.58	5.70	0.90	1.56	0.085	2.9	2.52	1.31	0.21	0.44	5.17
3	8	85.5	9.0	6.5	Loamy sand	6.60	5.80	0.85	1.47	0.079	3.4	2.70	1.50	0.24	0.53	6.00
4	12	81.1	11.1	7.8	Loamy sand	6.54	5.76	0.85	1.47	0.081	3.7	2.78	1.47	0.25	0.49	6.15
5	16	8.12	10.1	8.7	Loamy sand	6.50	5.70	0.81	1.40	0.077	2.2	2.82	1.56	0.27	0.55	6.06
6	20	79.6	11.2	9.2	Loamy sand	6.60	5.88	1.00	1.73	0.080	2.8	3.00	1.59	0.23	0.60	6.44

Dwb= Daniella wood biochar; %=percentage; H_20=water; Kcl=Potassium chloride; Org.c=Organic carbon; Org.m=Organic matter; N=Nitrogen; P=Phosphorus; Ca=Calcium; Mg=Magnesium; K=Potassium; Na=Sodium; CEC=Cation exchange capacity.

Table 2. After harvest routine physiochemical analyses of biochar amended soil.

S/N	Treatment DWB (tha^{-1})	Particle size % Sand	Distribution % Silt	% Clay	Textural class	pH H_2O 1:1	Kcl 1:1	Org.c %	Org.m %	N %	Available P Mg/kg	Ca	Exchangeable Cations Mg Meg/100 g	K	Na	CEC
1	0	74.3	12.2	13.5	Loamy sand	6.60	5.90	0.96	1.67	0.077	3.6	3.91	1.75	0.32	0.65	
2	4	81.4	10.5	8.1	Loamy sand	6.25	5.57	0.80	1.38	0.063	3.7	3.70	1.56	0.30	0.60	6.73
3	8	78.2	11.3	10.5	Loamy sand	6.70	5.98	0.96	1.68	0.079	3.9	3.92	1.78	0.35	0.68	7.40
4	12	81.1	10.2	8.7	Loamy sand	6.50	5.91	0.82	1.42	0.063	3.2	3.50	1.42	0.27	0.62	6.15
5	16	78.5	12.2	10.3	Loamy sand	6.60	5.98	0.95	1.64	0.009	4.1	3.70	1.57	0.29	0.58	6.88
6	20	78.6	11.9	10.1	Loamy sand	6.66	5.89	0.94	1.62	0.085	3.8	3.80	1.60	0.31	0.66	7.10

wood biochar rates on stem diameter in all sampling periods except at 4 weeks after sowing. At 2 and 3 weeks after sowing 4 tha^{-1} recorded the highest stem diameter while at 5 weeks after sowing 16 and 20 tha^{-1} recorded the highest stem diameter. At 6 weeks after sowing, application of 20 tha^{-1} of Daniella wood biochar recorded the highest stem diameter while at 7 weeks after sowing 16 tha^{-1} recorded the highest stem diameter; 20 tha^{-1} produced the highest stem diameter value of (1.63 cm) when compared with control which recorded the lowest stem diameter value (1.04 cm) at 8 weeks after sowing (Table 6).

Effect of Daniella wood biochar on biomass weight, fresh shoot weight, dry shoot weight, fresh leaf weight and dry leaf weight (gpot $^{-1}$) of maize

The results from this experiment revealed that 12 tha^{-1} of Daniella wood biochar produced significantly the highest fresh biomass weight, dry biomass weight, fresh shoot weight, dry shoot weight, fresh leaf weight and dry leaf weight values (221.4, 79.9, 140.0, 53.7, 81.4 and 32.5 gpot^{-1}) respectively (Table 7).

DISCUSSION

This study revealed that application of 20 tha^{-1} Daniella wood biochar had the highest pH of 6.60 in distilled water and 5.88 in acid solution. This shows that at pH 6.6 in distilled water, the soil is slightly acidic while at pH 5.8 in acid solution the

Table 3. Effect of Daniella Oliviera wood biochar on the height (cm) of maize.

Treatment DWB (tha^{-1})	2 WAS	3 WAS	4 WAS	5 WAS	6 WAS	7 WAS	8 WAS
0	22.4	36.1	52.3	62.0	67.0	76.7	81.0
4	32.2	52.7	70.5	89.2	105.4	115.0	138.7
8	30.7	50.9	63.6	80.2	97.2	106.5	117.6
12	31.2	48.5	67.6	84.4	97.8	122.8	142.2
16	25.3	44.4	59.1	73.0	91.5	107.2	126.5
20	21.6	43.6	53.1	66.7	93.8	113.7	126.4
mean	27.1	46.0	61.1	75.9	92.1	107.0	122.1
Significance	0.005**	0.016**	0.053NS	0.024**	0.005**	0.007**	0.011**
SEM±	1.76	2.73	4.09	5.07	5.02	6.36	9.44
LSD(0.05)	5.55	8.59	12.90	15.90	15.90	20.06	29.94
CV%	8.6	3.5	2.3	3.1	2.6	1.6	4.7

WAS = weeks after sowing; ** = Significant at 5%; NS = Not significant; SEM ± = Standard error of means; LSD = Least Significant difference; CV% = Coefficients of variation; DWB = Daniella wood biochar.

Table 4. Effect of Daniella oliviera wood biochar on number of leaves per plant.

Treatment DWB (tha^{-1})	2 WAS	3 WAS	4 WAS	5 WAS	6 WAS	7 WAS	8 WAS
0	5.00	6.00	8.33	10.00	11.33	13.33	15.00
4	5.00	7.33	9.00	10.67	12.67	15.00	17.00
8	4.67	7.00	9.00	11.00	13.00	14.67	16.67
12	5.00	7.33	9.00	11.00	13.00	15.00	17.33
16	4.67	7.00	9.00	11.00	12.67	15.00	17.00
20	4.00`	6.67	9.00	11.00	13.00	15.33	17.33
Mean	4.72	6.86	01.1	10.78	12.61	14.72	16.72
Significance	0.036**	NS	0.030**	NS	0.003**	0.001**	0.001**
SEM±	0.202	0.292	0.136	0.272	0.228	0.228	0.202
LSD (0.05)	0.636	0.920	0.429	0.858	0.718	0.718	0.636
CV %	2.0	7.3	1.1	1.8	1.5	1.3	1.5

Table 5. Effect of Daniella Oliviera wood Biochar on the leaf area (cm^2) of maize.

Treatment DWB (tha^{-1})	2 WAS	3 WAS	4 WAS	5 WAS	6 WAS	7 WAS	8 WAS
0	19.9	101.6	136.0	199.0	251.0	288.0	317.0
4	35.9	154.5	209.0	344.0	420.0	447.0	479.0
8	35.6	128.9	249.0	420.0	469.0	473.0	528.0
12	34.5	161.8	255.0	453.0	453.0	490.0	538.0
16	30.2	132.0	215.0	319.0	407.0	455.0	508.0
20	23.1	121.9	199.0	330.0	410.0	417.0	537.0
Mean	29.9	133.5	211.0	356.0	402.0	438.0	485.0
Significance	NS	0.001**	NS	0.002**	0.031**	0.046**	0.049**
SEM+	3.81	5.01	30.6	29.8	39.2	40.6	46.
LSD (0.05)	11.99	15.79	96.5	93.9	123.5	128.0	147.0
CV%	19.8	3.1	4.4	6.1	8.1	3.7	4.7

soil was moderately acidic. This is in agreement with Nguyen (2008) who reported that biochar amended soil had higher pH values, as pH values for different soil biochar combinations increased as the level of biochar

Table 6. Effect of Daniella Oliviera wood Biochar on stem diameter (cm) of maize.

Treatment DWB (tha^{-1})	2 WAS	3 WAS	4 WAS	5 WAS	6 WAS	7 WAS	8 WAS
0	0.42	0.54	0.63	0.68	0.85	0.97	1.04
4	0.72	0.89	1.00	1.18	1.22	1.49	1.32
8	0.70	0.85	1.00	1.27	1.33	1.38	1.57
12	0.65	0.77	1.11	1.28	1.35	1.44	1.46
16	0.53	0.68	1.11	1.29	1.41	1.51	1.63
20	0.56	0.72	1.17	1.29	1.42	1.50	1.63
Mean	0.59	0.75	1.00	1.16	1.26	1.38	1.44
Significance	0.011**	0.021**	NS	<0.001**	<0.001**	0.025**	<0.001**
SEM+	0.049	0.058	0.076	0.072	0.056	0.101	0.061
LSD (0.05)	0.154	0.183	0.240	0.229	0.176	0.317	0.193
CV %	11.6	3.4	3.6	3.4	1.6	5.2	2.3

Table 7. Effect of Daniella wood Biochar on biomass weight, fresh shoot weight, dry shoot weight, fresh leaf weight and dry leaf weight ($gpot^{-1}$) of maize.

Treatment DWB (tha^{-1})	FBW	DBW	FSW	DSW	FLW	DLW
0	91.2	46.6	56.1	27.4	36.1	24.0
4	168.6	55.0	108.8	30.5	59.8	17.9
8	175.3	63.0	108.3	43.2	67.0	20.3
12	221.4	79.9	140.0	53.7	81.4	32.5
16	181.8	68.5	120.4	45.0	61.5	26.5
20	180.0	76.2	119.7	47.6	60.4	26.2
Mean	169.7	64.9	108.9	41.2	61.0	24.0
Significance	0.048**	NS	0.018**	0.038**	NS	NS
SEM+	23.23	7.40	13.00	5.32	13.24	3.92
LSD (0.05)	73.12	23.32	40.95	16.77	41.71	12.36
CV	3.7	0.7	5.5	4.9	4.8	5.8

** = Significant at 5%; NS=Not significant; DWB = Daniella wood Biochar; FBW = fresh biomass weight; DBW = dry biomass weight; FSW = fresh shoot Weight; DSW = dry shoot weight; FLW = fresh leaf weight; and DLW = dry leaf weight.

increases. Soil analysis before sowing revealed that 20 tha^{-1} had the highest organic carbon and organic matter. However, 4 tha^{-1} recorded the highest total nitrogen values while 12 tha^{-1} recorded the highest available phosphorus. This was also reported by Davis and Wilson (2005); Li et al. (2000) and Preston and Schmidt (2006). Analysis of the nutrient content of biochar by Laird et al. (2007) revealed that biochar amendments in the soil (0,5, 10 and 20 bichar kg $soil^{-1}$) showed greater water retention, larger specific surface areas, high cation exchange capacity and higher pH values relative to the Un-amended treatments and biochar amendments significantly increased total N (up to 7%) and organic carbon (69%).

The soil analysis after harvest revealed that application of 8 tha^{-1} of Daniella wood biochar recorded the highest pH of 6.70 in distilled water while 8tha^{-1} and 16tha^{-1} recorded the highest pH of 5.98 in acid solution. This agrees with Nguyen (2008) who reported that biochar amended soil have higher pH values. However 16tha^{-1} recorded the highest available phosphorus while the highest calcium, magnesium, potassium, sodium and cation exchange capacity values was recorded by 8 tha^{-1}.

This result is same with Mann (2002); Lehmann et al. (2003); and Lehmann (2007) who reported that term prate soils rich in biochar have higher essential nutrients such as phosphorus, calcium, sulphur, Nitrogen and cation exchange capacity (CEC). The study revealed that Daniella oliviera wood biochar improved growth parameters (plant height, numbers of leaves, leaf area,fresh shoot weight,dry shoot weight, fresh leaf weight, dry leaf weight and stem diameter) and plant biomass weight (fresh biomass weight and dry biomass weight) of maize 8 weeks after sowing . Unlike fertilizer, biochar has an extremely long life in soils, biochar is carbon rich and gives it the ability to stay long in the soil by not being susceptible to biological degradation.

Biochar also attracts microbes and beneficial fungi, holds on to nutrients that are put into the soil. That means biochar works better the second and, third year than it does the first because it takes time to decompose in the soil (Husk and Major, 2011).

There was a significant difference between treatments in plant height, number of leaves, leaf area and stem diameter because application of 12 tha^{-1} of Daniella wood biochar produced the highest plant height and the largest leaf area while 12 and $20tha^{-1}$ produced the highest number of leaves when compared to other treatments. Also 20 tha^{-1} recorded the highest stem diameter. These results are in agreement with Blackwell et al. (2009); Lehman and Rondon (2006) and Peng et al. (2011) who reported that the effect of biohchar on soil quality and crop productivity has been observed to vary among treatments alike, but is generally positive. 12 tha^{-1} produced the highest fresh biomass weight, dry biomass weight, fresh shoot weight, dry shoot weight, fresh leaf weight and dry leaf weight compared to other treatments. However, the least performing treatment in terms of plant height, number of leaves, leaf area, stem diameter and plant biomass is control (unamended pot). This agrees with Blackwell et al. (2009); Lehmann et al. (2006a); Peng et al. (2011); and Van Zwietan et al. (2010) who reported that large yield improvements were obtained when biochar was applied in acidic soil like oxisols up to 30% over unamended plots (control).

Conclusion

From the study it was established that application of 12 tha^{-1} Daniella wood biochar produces the highest means of plant height, leaf area, fresh shoot weight, dry shoot weight, fresh leaf weight, dry leaf weight and plant biomass weights, while 20 tha^{-1} produces more leaves and higher stem diameter of the crop. Application of 12 tha^{-1} of Daniella wood biochar is more suitable for the growth of maize.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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