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SOIL BULK DENSITY AND GROWTH OF MAIZE (*Zea mays L.*) AS INFLUENCED BY COMPOST AND/ OR BIOCHAR IN ALFISOLS OF NORTHERN NIGERIA

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ABSTRACT

Soils are depleted of nutrients following intensive agriculture, leading to low yields. Therefore, adopting practices that increase soil organic matter is necessary. This study assessed the effects of compost, biochar, co-composted biochar and compost + biochar on soil bulk density and parameters of maize in Alfisols of Northern Guinea Savanna of Nigeria. Soils were amended with 5, 10, 15 t/ha, and NPK recommended including a control treatment, replicated nine (9) times yielding 126 experimental pots, planted with SAMMAZ 16. Pots were laid out in a complete randomized design. Soil bulk density was measured at 4, 8 and 12 weeks after sowing (WAS). Meanwhile, plant height, stem girth and number of leaves were measured at two (2) weeks interval for six (6) weeks. Analysis of Variance was used on the data collected and significant means were separated at $p \leq 0.05$ using Duncan Multiple Range Test. Results showed that compost + biochar at 15 t/ha reduced bulk density by 27, 14, and 15.69 % at 4, 8 and 12 weeks respectively. Plant height had increases of 18.74, 17.14 and 10.16 % at 2, 4 and 6 WAS using 10 t/ha of compost + biochar. Application of 5 t/ha compost enhanced stem girth by 51.67, 50.55 and 46.62 % at the various data collection times. Therefore, application of 10 t/ha compost + biochar is recommended in lowering bulk density and enhancing the parameters of maize.

Keywords: Bulk Density, Maize, Compost, Biochar, Maize Parameters, Alfisols

INTRODUCTION

Agricultural soils are prone to fertility depletion and unsustainable use owing to the extreme exertion of pressure resulting from mechanization and intensive agricultural activities (Mensah *et al*., 2018) leading to reduced soil organic matter. These menaces are instrumental for increase in soil bulk density, penetration resistance and reduced level of air and water flux of the soil. Soil properties are key in sustaining crops' growth and development; therefore, their poor status has the potential of reducing crop growth resulting in reduced final yield (Dukus *et al.*, 2011). To effectively address the problems limiting crop production, it is necessary to adopt appropriate approaches to soil management and increase soil organic matter through the application of compost, biochar, co-composted biochar (Naba, 2018).

According to Environmental Protection Agency (EPA), (2010), compost consists of partially degraded waste materials from rapid microbial degradation of plant and animal wastes under regulated aerobic conditions. Crucially, compost supports crop establishment and long-term yields by supplying crop-available nutrients and trace elements (Muhammad & Jan, 2016). The application of compost lowered soil bulk density and improve total porosity, saturated hydraulic conductivity and aggregate stability compared to the application of mineral fertilizer (Jenberu, 2017). Pyrolysis of biomass materials under limited oxygen supply leads to biochar (International Biochar Initiative (IBI), 2014). The application of biochar reduces bulk density (Negis, 2019) while increasing total porosity and water holding capacity (Omondi *et al*., 2016), soil pH, organic carbon and cation exchange capacity (Ding *et al*., 2016). Biochar application enhanced growth of maize due to the modification of soil quality due to the presence of organic matter (Blackwell *et al*., 2009).

Biochar is either co-composted or blended with a matured compost (Naba *et al*., 2020). Larney & Angers, (2012) reported that increasing rates of co-composted biochar resulted in increased soil total porosity, which in turn affected saturated hydraulic conductivity and moisture content. Soil application of co-composted biochar increased the final yield of maize by 98 – 150 % (Uzoma *et al.*, 2011). Furthermore, Vaccari *et al*. (2011) and Major *et al*. (2010) in their separate studies for two good seasons, observed in the second year that the application of co-composted biochar (at a rate of 20 t ha^{-1}) significantly increased maize yield by 28 %, 30 % and 140 % relative to the control. Therefore, soil application of organic amendments is key in reducing the use of mineral fertilizer while increasing the productivity of agricultural soils.

The studies carried out by Glaser *et al*. (2002) and Glaser & Birk, (2012) were evidential that soil application of sole biochar, in most scenario, rarely enhance the supply of plant essential nutrient for growth and development. Similarly, Manseh *et al*. (2018) reported that soil amendment with compost has a potential disadvantage of rapid microbial degradation. Other studies reported enhanced soil physical, hydraulic and chemical properties by the virtue of the synergistic effect of the application of the combination of compost and biochar (Glase & Birk, 2012; Trupiano *et al.*, 2017 and Manseh *et al*., 2018). Combined application of compost and biochar elongates the stability of compost in the soil while solving the menace of plant nutrients supply insufficiency of biochar amendment (Qian *et al*., 2023). Co-composting of biochar and compost enhances compost's nutrients supply, safety and stability (Qian *et al*., 2023). Meanwhile, the interaction between biochar and compost changes biochar's surface chemistry (Antonangelo *et al.*, 2021). It is hypothesized that the application of compost, biochar, co-composted biochar and compost + biochar will enhance soil bulk density and the parameters of maize in a Northern Guinea Savannah Alfisols of Samaru, Nigeria.

MATERIALS AND METHODS

Geo-information of the study area

Samaru is located on the northern plains of Nigeria and lies between latitude 11^{o}00' to 11^{o}28' North and longitude 7^{o}30' to 7^{o}52' East. It lies at an altitude of about 686 m above sea level. It is within the Guinea Savanna with two distinct dry and rainy seasons. The long time (1968 - 2017) means annual rainfall of the study area is 1015.9 mm and is concentrated between the months of May and September (Yamusa & Abdukadir, 2020). The soils of the region are classified as Typic Haplustalf according to USDA Soil Taxonomy (Ogunwole *et al*., 2001). Dominant tree species found in the Zaria region are the Sau (*Isoberlinia doka),* Bambara *(Terminalia avicennioides)*, Fragrant Padri-tree (*Stereospermum kunthianum),* African peach *(Nauclea latifolia),* Wild custard apple (*Annona senegalensis)* and Sicklebush (*Dichrostachys cinerea)* (Ogunwole *et al*., 2001).

Production of biochar, compost and co-composted biochar

The pyrolysis of biochar was carried out using maize cobs collected from farms within Industrial Development Center Zaria located between latitude 11^o 9'13''N and longitude 7^o 39'45" E on 15/04/2021. Biochar was produced following the procedure used by Nafiu *et al*. (2021). The whole products after pyrolysis were stored in a plastic bag in preparation for laboratory analyses and soil application. The final yield of biochar was calculated as follow:

$$\text{Yield (\%)} = \frac{\text{weight of Final Products}}{\text{weight of Initial Samples}} \times 100 \quad (1)$$

Compost and co-composted biochar were produced using rice straw and dried Gmelina leaves (*Gmelina arborea)* as carbon sources on 05/04/2021. Meanwhile fresh mango (*Mangifera indica*) leaves and cow manure were used as green materials. The bio-materials were collected within the Institute for Agricultural Research farm (Latitude 11^{o}14'14'' N and Longitude 7^{o}38'65'' E). The plants and animal materials were piled up in layers under trees to provides shading and were covered with Polyethene to warm up the pile, after weighing. On reaching two (2) weeks of pilling, phosphate rock (5 % phosphate rock w/w) was incorporated into the 52 kg pile, and the pile was divided into two equal portions (25 kg each). Biochar and compost following the procedure described by Zainudin *et al*. (2020). Piles were left to mature by watering and turning at two week intervals till harvest. At harvest (on 05/07/2021), the final products were prepared for soil application. The prepared compost and biochar were mixed in the ratio of 50 % compost: 50 % biochar (w/w) as compost + biochar blend, which was used as a treatment. The amendments were also analyzed in the laboratory.

Soil sampling for screenhouse experiment

Soil sample (1000 kg) for screenhouse experiment was randomly collected from 0 to 30 cm depth in a fallowed field, measured 1,600 m^2, at Institute for Agricultural Research Farm. The farm is within Northern Guinea Savanna of Nigeria on Latitude 11^{o}14'14'' N and Longitude 7^{o}38'65'' E, having altitude of 610 m above sea level. It has a mean annual rainfall of 1015.9 mm (Yamusa & Abdukadir, 2020). Undisturbed core soil samples were also randomly collected from 0 – 30 cm depth, along the points of disturbed samples, using core rings of 98 cm^3 volume. The samples were covered with air-tight Polyethene sheets and taken to the laboratory for the measurement of physical and hydraulic parameters. Disturbed soil samples were homogenized and prepared for screenhouse studies and laboratory analyses.

Experimental setup and sowing of maize

The experiment consisted of 5,10 and 15 t/ha of each organic amendment (Table 1). Each treatment was thoroughly mixed with 9 kg of prepared soil totaling 14 treatments combinations including a control and sole NPK, were replicated 9 times giving rise to 126 experimental pots which were laid in a Complete Randomized Design in a screenhouse at Department of Crop Protection, Ahmadu Bello University, Zaria. The organic amendments were analyzed for nitrogen, phosphorus and potassium with the view to calculating quantities of mineral fertilizers needed to achieve NPK 120: 60: 60 to ensure a balanced nutrient supply for optimum productivity of maize, as shown in Table 1.

The individual organic amendments were evenly mixed with 9 kg soil in each plastic pot. Maize (SAMMAZ 16) seeds were sourced from IAR seed unit and sown 3 cm below soil surface at three (3) seeds per hole. Crop were thinned to one plant per stand at 10 days. Application of nitrogen, phosphorus and potassium straight fertilizers was carried out at 2 WAS while the remaining dose of nitrogen was supplied to the crop at 6 WAS. Weeding was carried out by hand-pulling. Soil columns were evenly rewetted using 2000 cm^3 of water at 3 days' interval for the first 6 weeks, and at 2 days' interval till the end of the experiment, due to increase in water requirement of crops following advancement in size. The uniform irrigation aimed at averting the influence of non-uniform water supply on both soil and maize parameters.

Table 1: Treatments combination

Treatment	Interpretation
CTL	7 kg soil
NPK	0 g BCH + 9 kg soil + 7.5 g NPK 15:15:15
CMP_5	23 g CMP + 9 kg soil + 3.1 g urea + 2 g SSP + 3.5 g MOP
CMP_{10}	46 g CMP + 9 kg soil + 1.6 g Urea + 1 g SSP + 1.8 g MOP
CMP_{15}	69 g CMP + 9 kg soil + 0.6 g Urea + 0.4 g SSP + 0.7 g MOP
BCH_5	23 g BCH + 9 kg soil + 4 g Urea + 1.3 g SSP + 3 g MOP
BCH_{10}	46 g BCH + 9 kg soil + 2 g Urea + 0.7 g SSP + 2 g MOP
BCH_{15}	69 g BCH + 9 kg soil + 1 g Urea + 0.4 g SSP + 1 g MOP
C-BCH_5	23 g C-BCH + 9 kg soil + 3.2 g Urea + 1.14 g SSP + 2 g MOP
C-BCH_{10}	46 g C-BCH + 9 kg soil + 1.6 g Urea + 0.7 g SSP + 1 g MOP
C-BCH_{15}	69 g C-BCH + 9 kg soil + 0.8 g Urea + 0.4 g SSP + 0.5 g MOP
CMP + BCH_5	23 g CMP + BCH+ 9 kg soil + 3.6 g Urea + 1.6 g SSP + 3.2 g MOP
CMP + BCH_{10}	46 g CMP + BCH + 9 kg soil + 1.8 g Urea + 0.8 g SSP + 1.6 g MOP
CMP + BCH_{15}	69 g CMP + BCH + 9 kg soil + 1 g Urea + 0.4 g SSP + 0.8 g MOP

CMP= compost, BCH= biochar, C-BCH= co-composted biochar, CMP + BCH= compost + biochar, CTL= control. 5, 10 and 15 represent 5, 10 and 15 t/ha of organic amendments

Measurement of plant parameters
The measurement of the growth parameters of maize was carried out by selecting and marking the top three plant in each replicate at day 14. Plant growth parameters were taken at two-weeks' intervals for periods of 6 weeks. The growth parameters measured were plant height, number of leaves and stem girth.

Laboratory analyses
The organic amendments and soil samples were passed through 2 mm mesh, and were analyzed for their chemical and physical properties in laboratories at the Department of Soil Science, Ahmadu Bello University Zaria, Kaduna State. The amendments were analyzed for pH (H_2O), total nitrogen, total phosphorus, potassium and organic carbon. Prepared soil samples were analyzed for their pH, organic carbon, nitrogen, phosphorus and potassium. Selected soil physical and hydraulic properties such as particle size, bulk density, particle density, dried mean weight diameter, saturated hydraulic conductivity and moisture retention were determined. Soil pH was determined in 1:25 soil or organic amendments/water suspension. The organic carbon was determined using Walkley – black dry combustion method as described by Nelson & Sommer, (1982). Total nitrogen was measured using macro Kjeldahl method as described by Bremner & Mulvaney, (1982). Total phosphorus was measured using Bray-1 method (Jackson, 1958). Soil potassium was determined in an atomic absorption spectrometer while Organic matter was calculated by multiplying organic carbon by 1.74
Soil particle size analysis was measured following the procedure outlined by Gee & Bauder, (1986). Bulk density was measured using the core method (Blake & Hartge, 1986). Soil particle density was determined following the procedure described by Blake, (1965). Dried mean weight diameter was determined following the protocol described by Kemper & Rosenau, (1986). Soil Ks was measured using the method described by Reynolds *et al*. (2002). Moisture retention was determined using a pressure plate membrane as described by Klute, (1986). Total porosity was calculated following the method of Obi, (2000).

Statistical analysis
Means and standard deviations were computed for the soil bulk density and maize parameters. A one-way analysis of variance (ANOVA) was used to evaluate the effects of different application rates of the treatments on the measured parameters, and differences between the treatments means were compared using Duncan Multiple Range Test at the 5 % level. All statistical analyses were performed using SAS statistical software versions 9.4.

Table 2: Properties of Experimental Soil

Physical Properties			
Sand (%)	Silt (%)	Clay (%)	Textural Class
56.80	28.30	14.90	Loam
D_b (Mg cm^{-3})	D_p (Mg cm^{-3})	TP (%)	MWD (mm)
1.46	2.29	35.33	2.36
Ks (cm/min)	FC (%)	PWP (%)	AWC (%)
1.73	25	14.10	10.09
Chemical Properties			
pH	OC (g/kg)	N (g/kg)	P (mg/kg)
6.83	5.90	0.80	1.70
K (mg/kg)			
1.70			

Db= bulk density, Dp= particle density, TP= total porosity, MWD= mean weight diameter, Ks= saturated hydraulic conductivity, FC= field capacity, PWP= permanent wilting point, AWC= Available water content, OC= organic carbon, N= total nitrogen, P= phosphorus, K= potassium

Table 3: Selected chemical properties of the organic amendments

Amendment	N (g/kg)	P (mg kg^{-1})	K (mg kg^{-1})	OC (g/kg)	OM (%)	pH	C:N
CMP	7.80	1.61	0.43	167.60	28.82	8.16	21.40
BCH	3.20	0.86	1.80	99.80	17.16	10.81	31.19
C-BCH	5.60	1.94	0.56	95.70	16.47	8.70	17.09
CMP + BCH	6.00	1.24	1.12	103.20	17.75	9.71	17.20

CMP= compost, BCH= biochar, C-BCH= co-composted biochar, CMP + BCH= compost + biochar, N = nitrogen, P = phosphorus, K = potassium, OC = organic carbon, OM = organic matter, C: N = carbon to nitrogen ratio.

RESULTS AND DISCUSSION

Effect of organic amendments of soil bulk density
The results of the present study indicated that soil application of all the organic amendments significantly ($p \leq 0.05$) reduced soil bulk density compared to the control across sampling (Table 4). Following the application of organic amendments, the resultant bulk density was within the optimal range for root growth (Arshad, 1996). The lowering of bulk density might be due to the application of organic amendments rich in organic matter, which modify the properties of the soil necessary for a reduction in bulk density. The presence of organic matter promotes the formation of soil aggregates, which are clusters of soil particles bound together by organic substances. Soil aggregates are surrounded by larger pore spaces which increase soil macro-porosity, allowing for better air and water movement. This reduces soil compaction and subsequently lowers soil bulk density (Gregorich *et al.*, 1994).

Organic matter can also coat soil particles thereby reducing their packing density, leading to increased soil pore spaces and the consequent lowering of soil bulk density (Grossman & Reinsch, 2002). In the present study, there was an increase in soil bulk density with sampling periods. The increase in bulk density might be a direct consequence of reduced organic matter due to degradation by fungi and bacteria through processes of decomposition, mineralization and humification. These processes reduce soil organic matter content over time (Lehman *et al.*, 2020), leading to increase in bulk density.

Effect of organic amendments on plant height

Soil application of organic amendments in the present study significantly ($p \leq 0.05$) enhanced plant height of SAMMAZ 16 at all data collection phases, compared to the control and sole NPK fertilizer (Table 5). The positive outcome might have resulted from the NPK fertilizer added to the experimental soils at 2 WAS, as well as the increase in Nitrogen content of the soil following the application of organic amendments. The significant increases observed in the present study might also be due enhanced organic matter by amendments providing essential nutrients to maize thereby promoting its growth (Masto *et al.*, 2019). Conversely, Olsen *et al*. (2019) reported that the application of organic amendments could not significantly enhance PH. The negative result was attributed to the slow release of nutrients by organic amendments, which may not meet the immediate nutrient demands of maize plant, thereby limiting their increase in height.

The application of other amendments yielded higher plant heights compared to biochar. This might be due to their initial higher nitrogen and phosphorus contents. The least performance of biochar with respect to plant height might be attributed to its initial lower nitrogen and phosphorus content which resulted in reduced supply after exhausting the one supplied by mineral fertilizer added to the soil. In the present study, the plant height of maize increased with higher doses of organic amendments. The increase might be due to enhanced organic matter with higher application rates of organic amendments, which provides essential plant nutrient elements such as, nitrogen, phosphorus and potassium to crops resulting in improved plant height and plant growth (Abbas *et al.*, 2020). The plant height of maize decreased with increasing application rates of biochar amendment. The observed decrease might be a direct consequence of the immobilization of nutrient elements such as iron, coper, zinc due to increase of soil pH and adsorption of nutrients on its surface (Rodriguize-Vila *et al*., 2022).

Effect of organic amendments on stem girth

Stem girth of maize ranged from 0.80 cm in sole NPK amended soil to 1.93 cm in soils amended with 15 t/ha of compost + biochar, at 2 WAS (Table 6). At 4 WAS, it ranged from 0.90 cm in the control to 2.03 cm using 15 t/ha of compost + biochar. The least stem girth at 6 WAS was recorded in the control (1.00 cm) while the highest was with 10 t/ha of compost + biochar (2.10 cm). The significant ($p \leq 0.05$) improvement in terms of stem girth might be due to increased soil water holding capacity by organic amendments, which can help maintain adequate soil moisture for plant growth and reduce water stress-induced reductions in stem girth (Ghosh *et al*., 2019). Improved water holding capacity equally reduces the frequency of irrigation, which positively impact maize stem girth (Ghosh *et al*., 2019).

Table 4: Effect of organic amendments on soil bulk density

Treatment (t/ha)	Bulk Density (Mg m^{-3})		
	4th WAS	8th WAS	12th WAS
Control	1.44^{a}	1.50^{a}	1.53^{a}
CMP_5	1.28^{b}	1.35^{cd}	1.38^{b-f}
CMP_{10}	1.23^{bcd}	1.33^{cde}	1.37^{b-f}
CMP_{15}	1.17^{d}	1.28^{de}	1.32^{fg}
BCH_5	1.25^{bc}	1.44^{b}	1.41^{a-d}
BCH_{10}	1.23^{bcd}	1.38^{bc}	1.40^{a-d}
BCH_{15}	1.17^{d}	1.33^{cde}	1.35^{c-g}
C-BCH_5	1.22^{bcd}	1.42^{bc}	1.43^{abc}
C-BCH_{10}	1.19^{cd}	1.34^{cde}	1.35^{c-g}
C-BCH_{15}	1.19^{cd}	1.28^{de}	1.40^{a-d}
CMP +BCH_5	1.25^{bc}	1.36^{bcd}	1.40^{a-d}
CMP +BCH_{10}	1.21^{cd}	1.39^{bd}	1.41^{a-d}
CMP +BCH_{15}	1.17^{d}	1.26^{e}	1.29^{g}
NPK (Recommend)	1.42^{a}	1.53^{a}	1.53^{ab}
SE(±)	0.021	0.026	0.023

Wk= week, CMP= compost, BCH= biochar, C-BCH co-composted biochar, CMP + BCH= co-composted biochar, SE = standard error, subscript 5, 10 and 15 represent 5, 10 and 15 t/ha of organic amendments. Means followed by the same letter (s) within the same column and the same week are not significantly different at .05 level of probability as determined by DMRT.

The stem girth of maize increase across treatments. The observed increase might be due to increase in organic matter as a result of higher application rates of organic amendments to the soil. Interestingly, the stem girths of maize crops grown on soil treated with biochar amendment were the least amongst all the organic amendments in the present study. The results might be attributed to the high adsorption capacity of biochar which immobilizes nutrients, making them less available for plant uptake. This resulted in nutrient deficiencies and reduction in the performance of maize (Steiner *et al*., 2007). The stem girths obtained in the present study are generally lower than those reported by Ahmed *et al*. (2019) in the soil of Zaria. The lower stem girth might be due to inefficient water uptake by the crops. During the first six (6) weeks of the cropping periods, the crops were irrigated with 2000 cm^3 of water at 3-days interval. Therefore, before the crops are due to be irrigated again, they become wilted, thereby closing their leaves.

This indicated that the irrigation was less than what is obtainable under field conditions and might have contributed to the inadequate development of stem girth in the present study.

Table 5: Effect of organic amendments on plant height

Treatments (t/ha)	Plant Height (cm)		
	4 WAS	**8 WAS**	**12 WAS**
Control	23.58^{h}	52.00^{f}	55^{f}
CMP_5	33.67^{e-h}	76.00^{bcd}	154.67^{abc}
CMP_{10}	39.57^{def}	75.67^{bcd}	148.33^{abc}
CMP_{15}	30.27^{fgh}	73.67^{bcd}	159.67^{ab}
BCH_5	32.500^{e-h}	62.00^{def}	118.67^{cde}
BCH_{10}	38.17^{d-g}	62.67^{def}	107.33^{de}
BCH_{15}	24.33^{h}	54.33^{ef}	98.00^{e}
C-BCH_5	47.00^{cd}	74.07^{bcd}	183.40^{a}
C-BCH_{10}	55.33^{bc}	81.33^{bc}	152.33^{abc}
C-BCH_{15}	48.16^{cd}	74.47^{bcd}	139.07^{bcd}
CMP + BCH_5	42.00^{de}	71.00^{cde}	126.70^{b-e}
CMP + BCH_{10}	70.43^{a}	114^{a}	146.67^{abc}
CMP + BCH_{15}	63.33^{ab}	89.33^{b}	152.67^{abc}
NPK (Recommended)	20.00^{gh}	60.67^{def}	98.10^{e}
SE(±)	3.336	5.308	11.578

WAS = week after sowing, CMP= compost, BCH= biochar, C-BCH= co-composted biochar, CMP + BCH= compost + biochar, SE = standard error, subscript 5, 10 and 15 represent 5, 10 and 15 t/ha of organic amendments. Means followed by the same letter (s) within the same column and under the same week are not significantly different at .05 level of probability as determined by DMRT.

Table 6: Effect of organic amendments on stem girth

Treatments (t/ha)	Stem Girth (cm)		
	4 WAS	**8 WAS**	**12 WAS**
Control	0.87^{d}	0.90^{d}	1.00^{fg}
CMP_5	1.80^{ab}	1.82^{abc}	1.87^{cd}
CMP_{10}	1.63^{ab}	1.80^{abc}	2.16^{abc}
CMP_{15}	1.33^{c}	2.00^{ab}	2.37^{a}
BCH_5	1.53^{abc}	1.60^{bc}	1.67^{de}
BCH_{10}	1.57^{abc}	1.53^{c}	1.23^{f}
BCH_{15}	0.97^{d}	1.10^{d}	0.83^{g}
C-BCH_5	1.50^{bc}	1.63^{abc}	1.90^{cd}
C-BCH_{10}	1.43^{bc}	1.77^{abc}	1.97^{bcd}
C-BCH_{15}	1.43^{bc}	1.70^{abc}	2.07^{abc}
CMP + BCH_5	1.47^{bc}	1.57^{c}	1.83^{cd}
CMP + BCH_{10}	1.47^{abc}	1.73^{abc}	2.10^{abc}
CMP + BCH_{15}	1.93^{a}	2.03^{a}	2.33^{ab}
NPK (Recommended)	0.80^{d}	0.93^{d}	1.33^{ef}
SE(±)	0.125	0.122	0.122

WAS = week after sowing, CMP= compost, BCH= biochar, C-BCH= co-composted biochar, CMP + BCH= compost + biochar, SE = standard error, subscript 5, 10 and 15 represent 5, 10 and 15 t/ha of organic amendments. Means followed by the same letter (s) within the same column and under the same week are not significantly different at .05 level of probability as determined by DMRT.

CONCLUSION

The present study indicates that the application of biochar, compost, co-composted biochar and compost + biochar enhanced soil penetration resistance and the growth parameters of maize. The application of compost + biochar at 15 t/ha led to a significantly higher reductions of bulk density. The response of the growth parameters of maize to organic amendments showed that the highest plant height was obtained in soils treated with 10 t/ha of compost + biochar. Application of compost at 5 t/ha yielded the highest stem girth compared to the remaining treatments in the study. Therefore, the present study recommends the application of compost + biochar at 10 t/ha in lowering soil bulk density and in enhancing maize growth parameters.

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