CHANGES IN THE PROPERTIES OF AN ULTISOL AMENDED WITH DOW DUNG AND ITS EFFECT ON OKRA (*Abelmoschus esculentus* L) YIELD IN ABAKALIKI SOUTHEAST NIGERIA.

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ABSTRACT
Okra (Abelmoschus esculentus L) is a popular vegetable crop with good nutritional significance but few data exist on its production. This study evaluated the effect of three rates of cow dung on soil properties and yield of okra in 2023 cropping season. The study was arranged as a Randozised Complete Block Design with four treatments and five replications. The result of the study showed significant ($p<0.05$) decrease in soil bulk density and increase in total porosity in cow dung amended plots. Soil exchangeable bases (Ca, Mg , Na, K) were significantly increased in amended plots relative to the control. Okra growth and yield were significantly higher in amended plots relative to the control but with non-significant yield effect between 10 and 20 t ha-^{1}. The study recommended the use of cow dung for production in the study area since it improved soil properties and increased okra yield..
Keywords; Soil properties, Tropical soils, Organic amendments, Erosion. Soil nutrient

INTRODUCTION
Nigerian soils are degrading at an alarming rate through continuous cultivation, deforestation and inappropriate farming systems (Oshushanya, 2011). Abakaliki soils are no exemption as Nwite and Alu (2018) reported degradation in soil physical and chemical properties due to intensive cultivation, slash and burn farming practices and over grazing. According to Aiyelari and Oshuanya (2008) these practices result in low organic matter content that makes fragile soils collapse under the influence of rain drop impact leading to soil degradation and erosion.

Nwite and Alu (2008) reported that the cost of inorganic fertilizers coupled with their attendant problems such as environmental risk and increase in soil acidity limited their usage by farmers. Thus, research interest in tropical countries has recently shifted to utilization of organic amendments as nutrient source in crop production (Njoku and Mbak, 2012). Research results by Mbah *et al*. (2023a) and Nnadi *et al*. (2019) showed that the use of organic manure not only improve of environmental conditions , reduce of cost of production but lead to increase in crop yield. Njoku and Mbah (2012) reported increased soil fertility in organic waste amended soil compared to control. Mbah *el al*. (2023b) in a study on the yields and heavy metal uptake of cocoyam (Xanthosomas saggitifolium) and effects on soil properties of different tillage practices and application of burnt rice husk dust in Abakaliki southeast Nigeria, report improved soil properties and increased cocoyam yield in rice husk dust amended plots relative to the control. Ojeniyi et al (2007) reported that poultry droppings effectively increased soil fertility, crop yield and nutrient contents of soil.

Okra (*Abelmoschus esculentus*) belongs to the family *Malvaceae*. It is an annual crop shrub that is cultivated mostly within tropical and subtropical regions across the globe and represents a garden crop as well as a farm crop. Durazzo *et al*. (2018) reported that okra seeds posses anticancer and fungicidal properties while Islam (2019) showed that the pods are good cure for dysentery, gonorrhea and urinary complications. According to Oluyemesi and Olusegun (2011) okra flour has huge potentials to be used to enrich foods in order to provide adequate nutrients for individuals for whom daily nutritional needs are not being met. However, research data on this important crop is few or non existent in the study area. The aim of this study is to find out the effect of cow dung on soil properties and yield of okra (Abelmoschus esculentus) in Abakaliki southeastern Nigeria.

MATERIALS AND METHODS
The Study Area.
This research was carried out in 2023 cropping seasons at the Teaching and Research Farm of Faculty of Agriculture and Natural Resources Management, Ebonyi State University, Abakaliki southeast Nigeria. The area lies between $06^{0}04^{1}$ N and longitude 08^{0} 05^{1}E in the derived savannah zone of Nigeria, The area is characterized by high temperature and high rainfall. The temperature of the area ranges between 27-37^{o}C with an average of 29^{O}C. The total rainfall ranges between 1500 to 2000 mm with a mean of 1700 mm. The soil is hydromorphic and belongs to the order Ultisol, within the Ezzangbo soil association derived from shale and classified as Typic Haplustult (FDALR,1985)

Sources of materials and soil sample collection

The cow dung was collected from animal science section of the faculty of Agriculture and Natural Resources Management of the university. The test crop (Okra seed) was purchased from Ebonyi State Agricultural Development Programme (EBADEP). At the beginning of the experiment in May 2023 cropping season, soil samples were collected from 4 observation points (at a depth of 0-20 cm) , air dried at room temperature (about $26^{O}C$) , passed through a sieve of 2 mm and analysed for the initial nutrient content of the soil. Also at 30 and 60 days after planting (DAP) undisturbed core soil samples of 150.6 cm^2 were collected from six observation points from each plot .The collected samples were used to determine the soil bulk density.

Land preparation and Treatment Application

The study commenced in May 2023. An area of land measuring 11 m by 12 m was used for the study. The land was cleared and the debris removed. The field was demarcated into plots and replicates. The experiment was laid out as randomized complete block design (RCBD) with four treatments and five replications. The treatments were control (C , no treatment), 5 t ha^{-1} cow dung (CD_5 - equivalent to 6 kg/plot), 10 t ha^{-1} cow dung (CD_{10} equivalent to 12 kg/plot) and 20 t ha^{-1} cow dung (CD_{20} . equivalent to 24kg/plot) . The land was divided into 20 plots with each plot measuring 2 m by 2 m . The different rates of the cow dung were carefully weighed and spread on the appropriate plots and replicates. They were incorporated into the soil during tillage with traditional hoe in 2023 cropping season

Two seeds of Okra were planted per hole at a distance of 50 cm by 50 cm intra and inter row. The plants were later thinned to one plant/hole at 7 days after germination to give a total plant population of 111,111 plants/hectare. Okra plant height (cm) was measured at 10 weeks. Weeds were hand picked and removed at four weeks intervals.

Laboratory studies

The method of Gee and Bauder (1986) was used to determine the soil particle distribution. The soil exchangeable bases (Ca, Mg, Na ,K) was determined by the method described by Thomas (1982). Soil organic carbon was determined by the Walkley and Black procedure (Nelson and Somners (1983) .Total nitrogen was determined using the method of Bremner *and Mulvaney* (1982).

The soil bulk density was determined by the method of Blake and Hartge (1986). The total porosity was calculated from the bulk density value using the formula;

$Tp = 100(1-Db/Dp)$

Where Db = Bulk density, Dp= Particle density assumed to be 2.65 gcm^{-3} and Tp= total porosity.

Yield determination

At maturity 7 Okra plants were selected per plot and tagged. The pods in each tagged plants were harvested, dried to 14 % moisture content. The dried pods/plot were weighed and the data converted to its hectare equivalent.

Data analysis

The data obtained from this study were subjected to statistical analysis using general linear software for randomized complete block design (RCBD) (SAS Institute Inc 1999) while treatment means were separated using Duncan multiple range test.

RESULTS AND DISCUSSIONS

Initial properties of the soil and cow dung

The analysis of the soil showed that the soil is sandy clay loam in texture (Table 1). Nnabude and Mbagwu (1999) reported that sandy clay loam soils are acidic, with low organic matter status, cation exchange capacity and other essential nutrients. The Table also showed that the cow dung contained higher Ca, Mg Na and K than the soil. Higher levels of available P, total nitrogen and organic carbon were also observed in CD compared to the soil.

Effect of cow dung (CD) on soil bulk density (bd Mgm^{-3}) and Total porosity (tp %).

Table 2 showed that application of the three rates of CD significantly ($p<0.05$) decreased the soil bulk density compared to control at 30 DAP . The bulk density values ranged between 1.32-1.44 Mgm^{-3} at 30 DAP with the highest value in the control. At 60 DAP observed bulk density values were non-significant but are higher than the values obtained at 30 DAP .. Bulk density is a soil physical parameter used extensively to evaluate soil compactness and has very influence on root growth and proliferation. The lower bulk density (bd) observed in the CD plots could be attributed to the effect of the amendment. The difference in bd at 30 and 60 DAP could be as a result of a number of factors such as content of organic matter, natural process of settling and structural collapse due to total raindrop impact on the soil surface. Nnabude and Mbagwu (1998) attributed the higher bd observed at later stage (60) relative to earlier stage (30) DAP to the breakdown of some organic material in the soil matrix due to increased compaction at this stage . The result on table 2 showed the order of bd increase at 60 DAP as $C<CD_5<CD_{10}<CD_{20}$. In a study on the effect of rice husk dust on selected soil physical properties and maize grain yield in Abakaliki southeaster Nigeria, Uguru *et al* (2015) reported decrease in soil bulk density in amended plots compared to the control. Similarly, Mbah et al.(2023a) reported decreased soil bd in organic waste amended plots relative to the control.

The table also showed significant ($p<0.05$) increase in soil total porosity (Tp) at 30 DAP in CD amended plots. The tp values at 30 DAP were 46, 48, 49 and 50% ,respectively for C, CD_5, CD_{10} and CD_{20}. Higher tp % values were observed in 30 compared to 60 DAP. The higher Tp values at 30 DAP relative to 60 DAP could be as a result of reduced

compaction as a result of lower soil bulk density. It could also be as a result of a combination of many factors such as content of organic matter (OM), natural process of settling and structural collapse due to total raindrop impact on the soil surface. Njoku and Mbah (2012) reported that organic materials have low densities and therefore, can improve the soil porosity and make it less dense. The result of this study is in tandem with those of Mbah *et al*.(2023b) and Albuerqe et al. (2015) when they studied the effects of organic wastes as soil amendment.

Effect of application of cow dung on soil Ca, Mg, K,and Na (cmolkg-^{1}) .

Application of cow dung significantly increased soil content of Ca, Mg, Na and K compared to the control (Table 3). Soil Ca , Mg, K and Na content ranged between 0.10-0.19, 0.09-0.32, 0-08-0.23 , and 0.06-0.18 cmolkg-^{1} , respectively. The observed Ca contents in CD_5, CD_{10} and CD_{20} amended plots were 30,60 and 90% higher than the control The increase in soil contents of Ca, Mg ,Na and K could be attributed to their higher contents in the cow dung (Table 1). Research result by Mbah *et al*. (2023c) showed improved soil content of exchangeable bases in organic waste amended plots relative to unamended plots. Similarly, Xiun *et al*.(2016) reported increase in soil exchangeable bases in plots amended with organic wastes compared to unamended plost. Agegnehu *et al*.(2016) observed that crop yield, plant nutrient uptake and soil physicochemical properties improved under organic soil amendments and nitrogen fertilization on Nitosols

Effect of Application of cow dung on growth and yield of okra

Application of CD significantly ($p<0.05$) increased the okra growth and yield compared to the control Table 4). Okra growth ranged between 72.7-102 cm and 2.0-4-6 **(**Mg ha^{-1}), respectively**.** The observed increase in growth and yield of okra observed in CD amended plots could partly be attributed to higher nutrient content of the CD and partly to the improved soil physical properties following their application. Research result by Sanni and Adenubi (2015) showed increased plant height in goat and pig manure amended plots relative to the control. Mbah *et al*.(2023a) reported increased maize grain yield in plots amended with fresh and decomposed rice husk dusk compared to unamended plots. In a study on varying effect of organic waste products on yields of market garden crops by Diallo *et al*.(2022) showed increase in crop yield in amended plots relative to the control. Similarly, Alar (2017) reported increase in potato yield in organic waste compost amended plots relative to the control. The result of this study is in line with those of Njoku and Mbah (2012) and Tajeda and Benitez (2020) who reported increased crop yield when they used organic wastes as soil amendments

CONCLUSION AND RECOMENDATION

The result of this study showed that application of the three rates of cow dung improved soil properties and increased the yield of okra. The highest improvement in the studied parameters were observed in CD_{20} rate of application. Though CD_{20} rate of application gave highest yield but it was not significant compared to CD_{10} t ha-^{1} rate of application. Thus CD_{10} t ha-^{1} rate of application was recommended for use in this study

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Table 1; Initial properties of the soil and Cow dung (CD)

Parameter	Unit	Soil	CD
Sand	g/kg	563	-
Silt	g/kg	358	
Clay	g/kg	69	
Texture	Sandy clay loam		
Available P	mg/kg	0.21	2.19
TN	%	0.09	0.98
OC	%	0.65	9.30
pH		4.78	
Mg	Cmol kg-^{1}	1.14	1.01
Ca	Cmol kg-^{1}	1.98	4.07
K	Cmol kg-^{1}	0.10	0.49
Na	Cmol kg-^{1}	0.17	1.60

CD=Cow dung

Table 2: Effect of cow dung on soil bulk density (Mgm-^{3}) and total porosity (%)

	Bulk density (BD)		Total porosity (TP)	
Treatment	30	60	30	60
C	1.44	1.50	46	43
CD5	1.39	1.48	48	44
CD_{10}	1.36	1.47	49	45
CD_{20}	1.32	1.47	50	45
LSD(0.05)	0.73	NS	2.3	NS

NS=Non significant, CD= cow dung

Table 3: Effect of application of cow dung (CD) on soil Ca, Mg, K, and Na

Parameter	Ca(**cmol kg-^{1}**).	Mg(**cmol kg-^{1}**).	K(**cmolkg-^{1}**).	Na(**cmolkg-^{1}**).
	0.10	0.09	0.08	0.06
C	0.13	0.23	0.14	0..11
Cd5	0.16	0.29	0.22	0.17
CD_{10}	0.19	0.32	0.23	0.18
CD_{20}	0,04	0.16	0,07	0.08
FLSD(0.05)				

Table 4: Effect of application of cow dung (CD) on growth (cm) and yield of Okra (Mg ha^{-1})

Treatment	Growth	Yield
C	72.3	2.0
CD5	90.6	3.1
CD_{10}	98.9	4.5*
CD_{20}	102..	4.6*
FLSD (0.05)	19..8	1.2