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Impact of Cocoa Pod Husk-Based Composts on Okra (*Abelmoschus esculentus* (L.) Yield and Soil Chemical Properties in South Western Nigeria

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Abstract

Cocoa pod husk (CPH) could be used to prepare composts which enhance soil fertility and crop yield. Therefore, this study investigated the influence of CPH-based composts on the yield of okra and soil chemical properties of Alfisol and Ultisol in south western Nigeria. The treatments applied comprised three CPH-based compost: CPH+ Neem leaf (CPH+ NL), CPH+ Poultry manure (CPH+ PM) and CPH+ PM + NL. The results were compared with soils treated with NPK 15-15-15 and a control that received neither NPK nor compost using two varieties of okra (NH47-4 and LD88) as test crops. The treatments were replicated three times in a randomized complete block design. Residual effects of the treatments were also observed. Pre- and post-cropping soil analyses were carried out. Data collected were subjected to statistical analysis using analysis of variance (ANOVA) with the means separated by Duncan multiple range test (DMRT). There was significant ($p<0.05$) difference in the fruit yield (FY) of okra with composts and NPK in both locations. On Alfisol, CPH + PM +NL produced the highest FY (4.80 t/ha) which was significantly higher than the other treatments. On Ultisol, CPH +PM + NL produced the highest FY (4.81 t/ha), however, there was no significant difference in the FY obtained from CPH+PM and NPK (3.88 and 3.78 t/ha respectively).The control produced the lowest yield on Alfisol and Ultisol (1.78 and 1.70 t/ha respectively). Residual effect of fertilizer was significant in both locations, CPH+PM+NL significantly produce the highest FY (3.53 and 3.48 t/ha respectively) on Alfisol and Ultisol. Variety LD88 produced FY (3.78 and 3.6 t/ha respectively) that was significantly higher than NH47-4 (3.7 and 3.48 t/ha respectively) in Alfisol and Ultisol in the main planting, however there was no significant difference between the varieties during the residual planting. The CPH-compost also improved the soil pH, N P, K, Ca and Organic Carbon (OC) content after the main and residual cropping in both Alfisol and Ultisol compared to the control and NPK treatments because the values obtained were higher than the initial soil test values. It was evident that CPH+PM+NL had significant impacts in improving soil fertility and okra yields in the selected soils.

Introduction

Cultivation of high-yielding crop varieties and multiple cropping practice are depleting soil fertility rapidly. Most tropical soils have low organic matter content due to limited accumulation of organic matter (Rainer, 2010), posing a major developmental constraint to crop production. To address this issue, both organic and inorganic fertilizers can play a crucial role in agricultural development.(Kumar *et al*., 2022) The benefits of chemical fertilizers have been well-documented since the 'green revolution', as they played an important role in enhancing agricultural productivity (Vriesmann *et al*., 2012).

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Crop production using inorganic fertilizers has not been sustainable due to high costs, scarcity and negative effects on soils such as acidification, leaching, nutrient imbalance and pollution (Herperlly et al. 2009). Therefore, there is a growing interest in utilizing agricultural wastes by the resource farmers. Recycling of nutrients as soil organic amendments can promote the sustainable use of agricultural waste and offer economic and environmental benefits (Diacono and Montemuro, 2010). Currently, various wastes like cocoa pod husks, plantain peels, rice husks, palm kernel cake wastes, potato peels, among others, are generated in large quantities and often abandoned in fields or littered in the surroundings, constituting foul odours, breeding grounds for pathogenic microorganisms and environmental pollutants (Adediran et al. 2003). The continuous accumulation of organic wastes poses a threat to the environment, yet these residues are potential sources of plant nutrients (Torma et al. 2018). Instead of burning these materials, which is a common practice among farming and urban communities, they could be effectively utilized through recycling.

Composting offers a practical and cost-effective solution to prevent wastage of valuable natural resources It helps in converting biodegradable organic wastes into products that can be safely used as bio-fertilizers and soil amendments (Yu et al. 2019). Compost can be a beneficial soil amendment for okra due to its ability to supply a balanced nutrient ratio, particularly a 1:2 ratio of nitrogen (N) to potassium (K), which is beneficial for okra growth. This natural source of nutrients can improve soil health and promote healthy okra plants In Nigeria, okra is primarily grown by small-scale farmers, and due to low input system commonly used for okra production, the yield of green pod is often relatively low. Even when high-yielding cultivars are planted, the inherently low fertility of the soil remains a limiting factor for production. While the positive response of okra to mineral fertilizer application has been reported in Nigeria (Olasantan, 1991), the problem lies in the scarcity and high cost of these fertilizers, making them inaccessible to local farmers. The solution then largely lies in organic fertilizers, which have been shown to be comparable to chemical fertilizer in improving yields and maintaining soil fertility (Wang et al., 2009). Thus, the objective of this study was to assess the potential of cocoa pod husk-based compost as a fertilizer to improve soil fertility and okra production.

Materials and Methods

Field trial

Alfisol is situated in Ibadan Oyo State on latitude 7^{o}25.0‘N and longitude 3^{o}50.5‘E in South Western Nigeria with an altitude of about 122 meters above sea level. It is in the derived savanna zone of Nigeria while the Ultisol is situated in Ogun state on latitude 6^{o}51‘N and longitude 3^{o}42‘E with mean altitude of 55 m above sea level in South Western Nigeria. It is in the rainforest zone of Nigeria. Three types of composts were prepared using cocoa pod husk (CPH), neem leaves (NL) and poultry manure (PM), following the procedure used by Yinda and Adeoye (1995). The compost that consisted of the three materials (CPH+PM+NL) had the highest N content of 23.3 g/kg. Phosphorus content ranged from 6.5 to 11.7 g/kg while K content ranged from 10.4 to 14.6 g/kg (Table 1).

Table 1. Nutrient contents of composts

Nutrient	Compost		
(g/kg)	CPH+PM+NL	CPH+PM	CPH+NL
N	23.3	20.6	19.9
P	11.7	8.2	6.5
K	14.6	12.8	10.4

CPH+PM+NL= Cocoa pod husk + Poultry manure + Neem leaf; CPH+PM= Cocoa pod + Poultry manure; CPH+NL=Cocoa pod husk + Neem leaf

The land was mechanically prepared through ploughing and harrowing, and the experiment was laid out in a Randomized Complete Block Design (RCBD) with treatments replicated three times. The plot size was 2.4 m by 2.4 m (5.76 m^2) with 1.5 m within rows and 1 m between plots. Four different fertilizer treatments were tested: (CPH + PM at 50 kg N/ha, CPH + NL at 50 kg N/ha, CPH + PM + NL at 50 kg N/ha and NPK at 50 kg N/ha), along with a control treatment without any fertilizer. These treatments were applied to two varieties of okra (NH47-4 and LD88). The experiment was replicated three times, resulting in a total of 30 experimental plots. The composts were applied two weeks before planting, and okra seeds were sown at a spacing of 60 cm x 60 cm, having a total of 50 plants/plot with 2 plants stand to give a plant population of 55,555 plants/ha. The inorganic fertilizer (NPK 15-15-15) was applied a week after planting.. Post-cropping soil samples were collected from each plot for chemical analysis.

Statistical analysis

Data on the fresh fruit yield of okra were collected. Soil samples were randomly taken from each plot after harvesting and analysed for their chemical properties. The collected data were analysed using analysis of variance (ANOVA), and the means separated by Duncan's Multiple Range Test (DMRT).

Laboratory analysis

The used for the experiment were analysed for chemical and physical properties before planting The soils (Alfisol and Ultisol) were collected on the field where the experiments was to be carried out within the depth of 0-15 cm. The soils were air-dried and passed through a 2 mm sieve. Representative samples were taken and analysed to determine the soil particle size, pH (H_2O), organic carbon, total nitrogen (N), available phosphorus (P) as well as exchangeable potassium (K), sodium (Na), calcium (Ca) and magnesium (Mg). Particle size analysis was determined using Bouyoucos hydrometer method (Sheldrick and Hand Wang, 1993). Soil pH was determined in water 1:1 soil water ratio (IITA, 1982). Total N was determined using the micro kjedahl digestion method (Bremner, 1996) while Organic carbon was determined by the procedure of Walkley and Black using the dichromate wet oxidation method (Nelson and Sommers, 1996). Available P in the soil was determined using Bray-1 method (Bray and Kurtz, 1945). Exchangeable K, Ca, Mg and Na were extracted with 1.0 N ammonium acetate (Hendershot and Lalande, 1993). Thereafter the amounts of K and Na in the filtrates were determined using flame photometer while Ca and Mg were determined using Atomic Absorption Spectrophotometer (AAS). The ECEC was calculated as the total sum of exchangeable bases and total exchangeable acidity.

Results

Initial soil properties before cropping

The soils (Alfisol and Ultisol) were moderately acidic (with pH values of 6.2 and 5.6, respectively) and both sandy loam in texture (Table 2). The respective

Table 2: Physical and chemical properties of pre-cropping soils

Parameters	Alfisol	Ultisol
pH (H_20) (1:1)	6.2	5.6
OC (g/kg)	9.4	7.2
Total N (g/kg)	0.9	0.7
Available P (mg/kg)	6	5
Exchangeable cations (cmol/kg)		
Ca^{++}	3.2	1.6
Mg^{++}	0.7	0.4
K^+	0.4	0.1
Na^+	0.2	0.2
Exchangeable acidity(Al^{3+} +H^+)	0.10	0.13
ECEC	4.60	2.43
Particle size (g / kg)		
Sand	686.0	776.0
Silt	104.8	124.8
Clay	209.2	109.2
Textural class	Sandy loam	Sandy loam

total N of the soils were low (0.9 and 0.7 g / kg) as the values were below the critical level of 1.6 – 2.0 g/kg while the available P values of the soils (6 and 5 mg/kg, respectively) were also below the critical level of 7-20 mg/kg (FFD. 2012). The K status of the Ultisol soil (0.1 cmol/kg) was less than the critical level of 0.31 cmol/kg while the K status of the Alfisol soil (0.4 cmol / kg) was higher than the critical level [12]. Similarly, the Na, Ca and Mg contents of the Alfisol were higher than that of the Ultisol. The soils were generally low in organic carbon (9.4 and 7.2 g/kg, respectively) because they were below the critical level of 10 – 14 g/kg (FFD. 2012). The soils were sandy loam in texture.

Effects of treatments on fruit yield of okra

There were significant differences ($p<0.05$) in the fruit yields of the two okra varieties with the application of composts and NPK fertilizer in both soils. In Alfisol, application of CPH + PM +NL resulted in the highest fruit yield (4.80 t/ha), which was significantly higher than the other fertilizer treatments

(Fig.1). In Ultisol, CPH+PM+NL also significantly produced the highest fruit yield (4.81 t/ha). There was no significant difference in the fruit yield obtained from CPH+PM and NPK (3.88 and 3.78 t/ha, respectively). The control treatment had the lowest yield in both the Alfisol and Ultisol with 1.78 and 1.70 t/ha, respectively.

Significant differences were also observed in the residual effects of amendments in both soils. In Alfisol, CPH+PM+NL produced the highest fruit yield (3.53 t/ha), and this was significantly higher than the other treatments as shown in Fig 1. On the other hand, there was no significant difference in the fruit yield obtained from CPH+PM and CPH+NL (3.11 and 2.98 t/ha, respectively); however, all the composts produced fruit yields that were significantly higher than NPK and control during the residual planting. In Ultisol, irrespective of the okra varieties, CPH+PM+NL produced the highest fruit yield (3.48 t/ha), significantly higher than CPH+NL and NPK (2.48 and 2.46 t/ha, respectively). The control treatment produced the least fruit yield (1.45 and 1.49 t/ha, respectively) at both Alfisol and Ultisol.

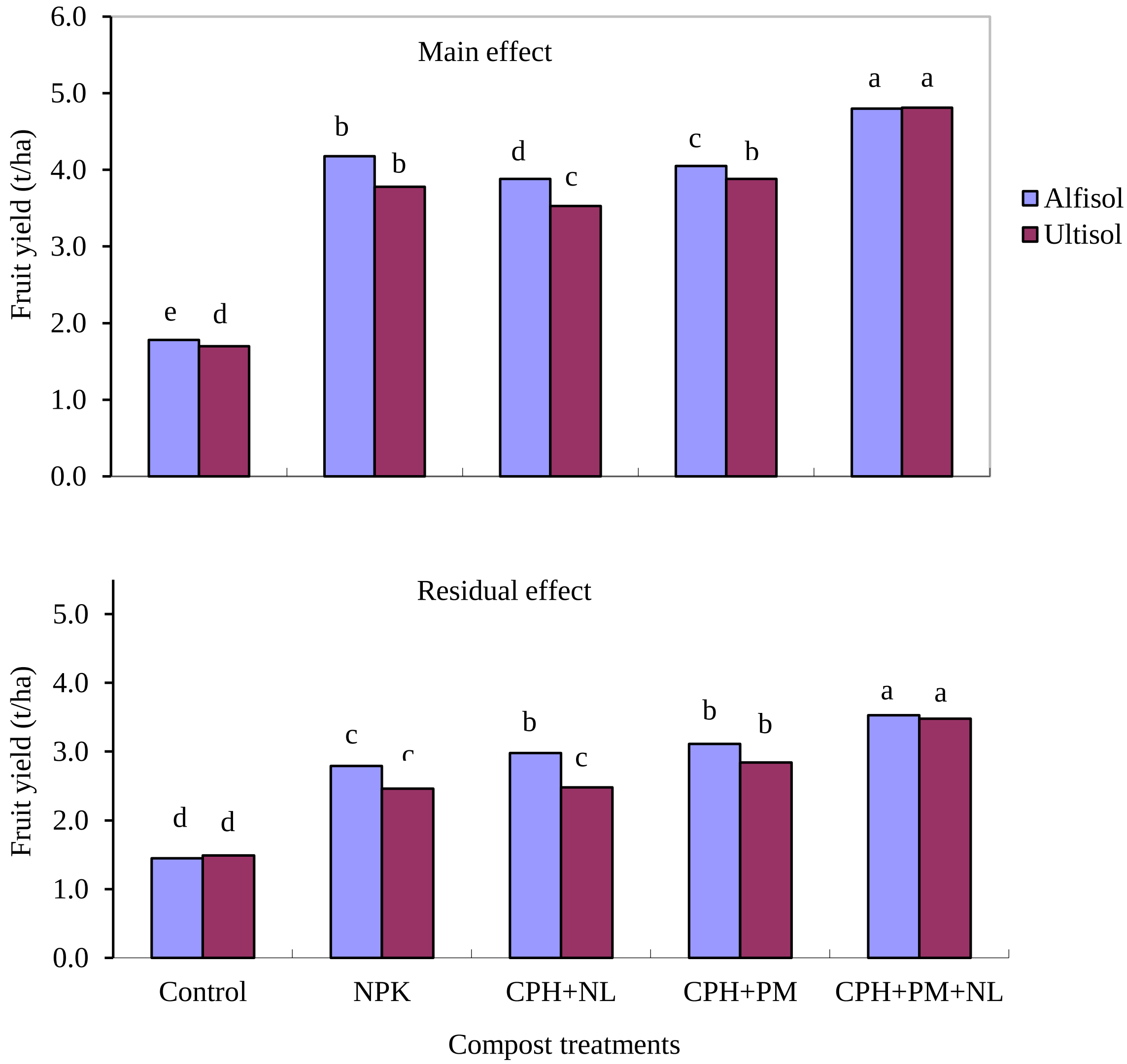

Fig. 1. Effects of the CPH-based composts and NPK fertilizer on the fruit yield of okra in Alfisol and Ultisol during (a) main and (b) residual cropping. Means with same letter in the same location are not significantly different at 5 % level of probability by Duncan's Multiple Range Test (DMRT)**.** CPH= Cocoa pod husk, PM= Poultry manure, NL= Neem leaf

The analysis of the effects of two okra varieties on the fruit yield in both main and residual cropping phases as illustrated in Fig. 2, indicated significant differences in yields between the two varieties during the main planting. In Alfisol and Ultisol, LD88 produced fruit yields (3.78 and 3.6 t/ha, respectively), which were significantly higher than NH47-4 (3.7 and 3.48 t/ha, respectively). However; there was no significant difference in the yield of okra varieties during the residual planting in both soils. In Alfisol, LD88 produced fruit yield (2.79 t/ha) that was not significantly higher than that of NH47-4 (2.75 t/ha). The same trend was observed in Ultisol with LD88 produced fruit yield (2.6 t / ha) that was not differed significantly from NH47-4 (2.5 t/ha).

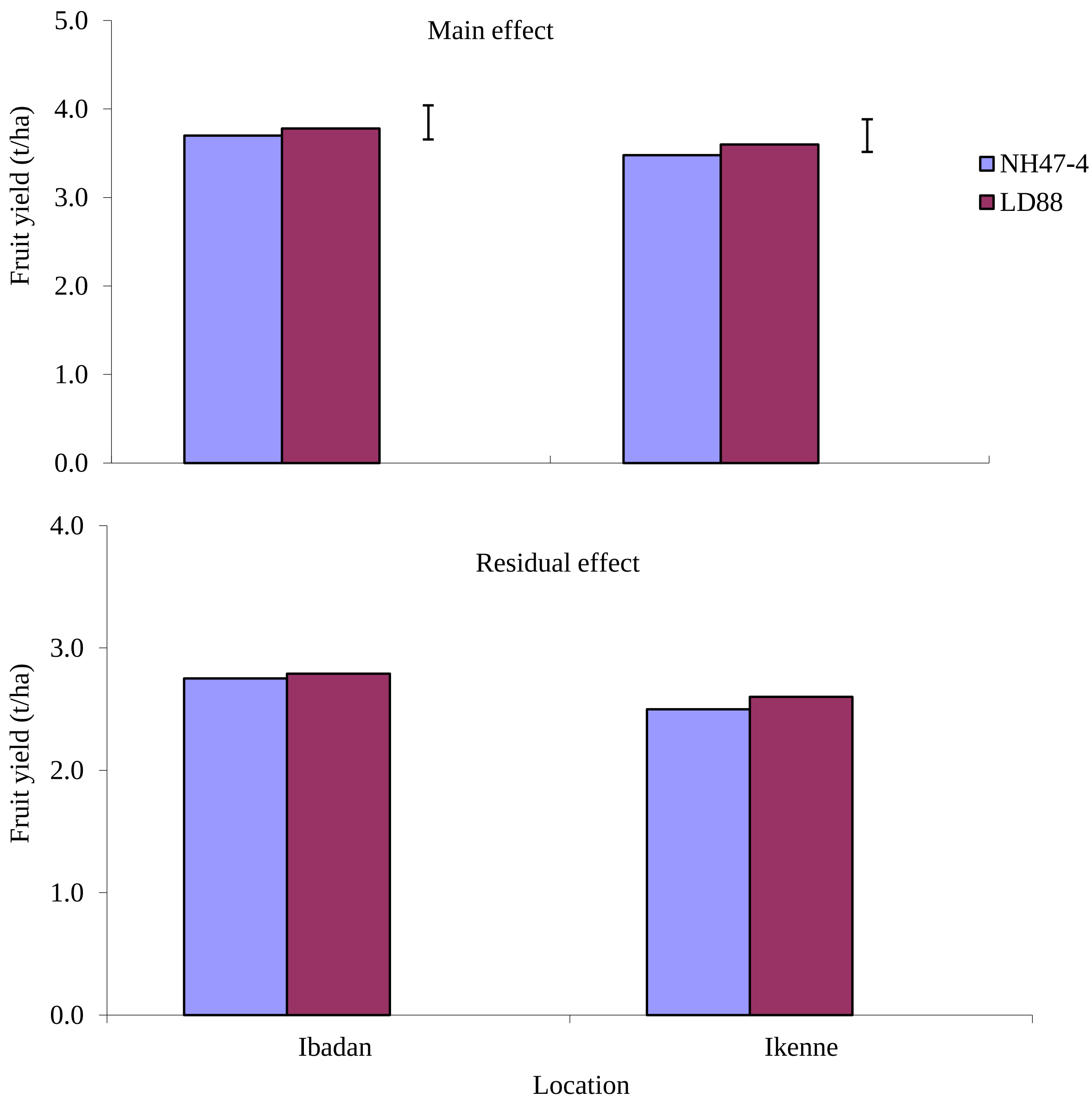

Fig. 2: Effects of the variety on the fruit yield (t / ha) of okra in both main and residual planting in Alfisol and Ultisol. Bar is LSD $_{(0.05)}$

Effects of treatments on soil chemical properties

The effect of variety was not significant on soil pH, N, Mg and K but it was significant ($p<0.05$) on OC, P, Ca and exchangeable Na in Alfisol. The soil on which LD88 was grown contained more OC, Ca and Na than where NH47-4 was grown. In Ultisol, the effect of varieties was not significant ($p<0.05$) on pH, OC, N, Ca and Na but it was significant on P, Mg and K (Tables 3 and 4). All the CPH-based composts increased soil pH compared to NPK fertilizer and control in Ultisol but the effect was not significant. The compost significantly increased soil pH in Alfisol but there was no significant effect of compost on pH in Ultisol. In Alfisol, CPH+PM+NL significantly enhanced soil pH more than NPK and control by 4.28 % and 7.82 %, respectively as shown in Table 3. In both soils, CPH+PM+NL had significant higher OC than NPK and control.The soil total N in Alfisol ranged between 0.8 – 1.1 g/kg for CPH-based composts compared to 0.8 and 0.6 g/kg for NPK and control, respectively. In Ultisol, soil total N ranged between 0.7 and1.0 g/kg for CPH-based compost compared to 0.7 and 0.6 g/kg for NPK and control, respectively. All the fertilizer types significantly enhanced total N compared to control in both soils. The fertilizer types significantly affected the available P in Ultisol. The application of CPH+PM+NL and CPH+PM significantly resulted in higher available P than control; however in Alfisol, there was no significant difference in the available P. The effect of composts on exchangeable Mg was significant in both soils. In Alfisol, CPH+PM+NL resulted in highest exchangeable Mg contents (1.8 cmol/kg), which was significantly higher than the control (1.2 cmol/kg) and other amendments (Tables 5). Furthermore, in Ultisol, CPH+PM resulted in highest Mg contents (1.6 cmol/kg) which was not significantly higher than that of CPH+PM+NL (1.5 cmol/kg) but significantly higher than control (0.9 cmol/kg) and other amendments. There was no significant difference in the exchangeable Ca among the fertilizer treatments. However, all the amendments significantly enhanced exchangeable Ca relative to control (1.5 cmol/kg) in Alfisol. In Ultisol, CPH+PM+NL resulted in increased Ca content (2.7 cmol/kg) that was significantly higher than those of other amendments and control (1.1 cmol/kg).

Table 3: **Chemical properties of soil as influenced by composts and NPK fertilizer applications after the main planting in Alfisol**

Treatments	pH(H_2O)	OC	N	P	Ca	Mg	K	Na
		(g / kg)		(mg/kg)	(cmol/kg)			
Variety								
NH47-4	6.6	14.50b	0.9	7a	2.1b	1.6	0.2	0.4b
LD88	6.6	14.84a	0.8	6b	2.3a	1.6	0.2	0.5a
	Ns		Ns			ns	Ns	
Fertilizer								
Control	6.2 c	10.3d	0.6c	4c	1.5b	1.2d	0.2	0.4b
CPH+NL	6.8a	15.5b	0.8b	6b	2.5a	1.6c	0.2	0.5a
CPH+PM	6.5b	14.2c	1.0a	7b	2.4a	1.7bc	0.2	0.4b
CPH+PM+NL	6.8a	17.5a	1.1a	9a	2.3a	1.8a	0.2	0.4b
NPK	6.5b	15.7b	0.8b	6b	2.4a	1.7b	0.2	0.4b
							ns	
V*F	ns	*	ns	*	ns	*	*	*

ns - not significant; *- significant.

Means with same letter (s) in a column under the same treatment are not significantly different at 5 % level of probability by Duncan's Multiple Range Test (DMRT)

CPH= Cocoa pod husk, PM= Poultry manure, NL= Neem leaf

Table 4: Chemical properties of soil as influenced by compost and NPK fertilizer applications after the main planting in Ultisol

Treatments	pH(H_2O)	OC	N	P	Ca	Mg	K	Na
		(g/kg)		(mg/kg)	(cmol/kg)			
Variety								
NH47-4	6.3	19.4	0.8	4a	2.2	1.0b	0.2	0.3
LD88	6.2	19.3	0.7	3b	2.1	1.2a	0.2	0.3
	ns	ns	ns		ns		ns	ns
Fertilizer								
Control	6.0	8.2c	0.6d	3c	1.1d	0.9b	0.1c	0.3
CPH+NL	6.2	19.9b	0.6d	3c	2.1c	0.8b	0.2a	0.3
CPH+PM	6.4	21.0a	0.9b	4b	2.3b	1.6a	0.2a	0.4
CPH+PM+NL	6.5	21.2a	1.0a	5a	2.7a	1.5a	0.2a	0.4
NPK	6.1	19.6a	0.7c	3c	2.4b	0.8b	0.2a	0.3
	ns							ns
V*F	ns	ns	*	*	*	*	*	ns

ns - not significant; *- significant.

Means with same letter (s) in a column under the same treatment are not significantly different at 5 % level of probability by Duncan's Multiple Range Test (DMRT)

CPH= Cocoa pod husk, PM= Poultry manure, NL= Neem leaf

Residual effects of treatments on soil chemical properties

The residual effects of composts and NPK fertilizer applications on chemical properties of Alfisol showed that the varietal effect was not significant for all the parameters measured (Table 5). The soil in which NH47-4 was grown contained higher levels of N, OC, K and Na compared to the soil where LD88 was grown. In Ultisol, the effect of varieties was significant on Mg but not on N, OC, Ca, K, P and Na contents (Table 5). The soil where NH47-4 was cultivated had higher OC, N and Mg levels but lower levels of P and K compared to where LD88 was grown. The application of composts had significant effects on residual NS, OC, P, Mg, Ca and K in both soils. It was observed in both soils that CPH-based composts significantly enhanced pH more than NPK and the control (Tables 5 and 6).The OC contents of the soils were significantly increased by CPH- based composts. The OC contents. In Alfisol, the OC increased from the initial value of 9.4 g/kg (Table 1) to values ranging from 13.00 - 14.95 g/kg soil for CPH-based composts (Table 6), compared to 7.8-11.5 g/kg soil for the control and NPK, respectively. In Ultisol, the OC contents increased from the initial value of 7.2 g/kg soil (Table 2) to values ranging between 17.0 and 17.8 g/kg for CPH-based composts, compared to 8.4 - 12.8 g/kg for the control and NPK respectively (Table 6). The soil total N content in Alfisol ranged from 0.7 - 0.9 g/kg for CPH-based composts compared to 0.4 - 0.6 g/kg soil for control and NPK, respectively. In Ultisol, soil N ranged from 0.5 - 0.8 g/kg for CPH based compost compared to 0.4 g/kg for control and NPK. The CPH-based composts significantly enhanced soil total N compared to the control and NPK in both soils (Tables 5 and 6). The CPH-based composts and NPK fertilizer applications significantly affected the soil P in both soils. In Alfisol, there was no significant difference in the P value obtained from soil treated with CPH-based composts and NPK but the control gave the least P value (2 mg/kg), which was significantly lower than all the other CPH-based composts and NPK fertilizer treatments. However, in Ultisol, CPH+PM+NL resulted in higher available P (4 mg/kg) which was significantly higher than the other CPH-based composts, NPK and control. The soils' exchangeable Mg contents increased with the application of fertilizer. In Alfisol, CPH+PM+NL treated soil recorded Mg value of 1.29 cmol/kg which was not significantly higher than other treated soils but significantly higher

Table 5. Chemical properties of soil after the residual cropping of okra in Alfisol

Treatments	pH(H_2O)	OC	N	P	Ca	Mg	K	Na
		(g/kg)		(mg/kg)	(cmol/kg)			
Variety								
NH47-4	6.6	12.3	0.7	5	1.1	1.1	0.4	0.9
LD88	6.7	12.2	0.6	5	1.1	1.2	0.3	0.8
	ns	ns	ns	ns	ns	ns	ns	ns
Fertilizer								
Control	6.0c	7.8c	0.4d	3c	0.7c	0.8b	0.3b	0.3b
NPK	6.2b	11.5b	0.6c	4b	1.0b	1.1a	0.4a	0.2b
CPH+NL	6.9a	13.0ab	0.7b	5a	1.3a	1.2a	0.4a	0 .6a
CPH+PM	6.9a	14.1ab	0.8b	5a	1.3a	1.2a	0.4a	0.6a
CPH+PM+NL	6.9a	15.0a	0.9a	5a	1.3a	1.3a	0.4a	0.6a
V*F	ns	ns	ns	ns	ns	ns	ns	ns

Table 6. Chemical properties of soil after the residual cropping of okra in Ultisol

Treatments	pH(H_2O)	OC	N	P	Ca	Mg	K	Na
		(g /kg)		(mg /kg)	(cmol/kg)			
Variety								
NHA7-4	6.5	16.2	0.6	2	2.2	1.2a	0.2	0.3
LD88	6.4	16.1	0.5	2	2.3	1.0b	0.2	0.3
	ns	ns	ns	ns	ns	*	ns	ns
Fertilizer								
Control	6.1c	8.4c	0.4d	2c	0.9d	0.7c	0.2	0.2b
NPK	6.0c	12.8b	0.4d	3b	2.6b	0.8c	0.2	0.3a
CPH+NL	6.5b	17.0a	0.5c	3b	2.3c	1.2b	0.2	0.3a
CPH+PM	6.6ab	17.0a	0.7b	3b	2.6b	1.6a	0.2	0.3a
CPH+PM+NL	6.8a	17.8a	0.8a	4a	2.8a	1.2b	0.2	0.3a
							ns	
V*F	ns	ns	ns	*	*	ns	*	*

ns - not significant; *- significant.

Means with same letter (s) in a column under the same treatment are not significantly different at 5 % level of probability by Duncan's Multiple Range Test (DMRT)

CPH= Cocoa pod husk, PM= Poultry manure, NL= Neem leaf

than the control (0.8 cmol/kg. In Ultisol, CPH+PM treated soil recorded the highest Mg value (1.2 cmol/kg) which was significantly higher than NPK and control. There was no significant difference in the exchangeable Ca levels in soils treated with CPH-based composts. The exchangeable Ca content was significantly higher in Alfisol than NPK and control treatments. In Ultisol, the CPH+PM+NL treated soil had the highest exchangeable Ca level (2.8 cmol/kg) which was significantly higher than NPK (2.6 cmol/kg) and control (0.9 cmol/kg). Potassium levels in both soils were not significantly affected by CPH-based composts but they were significantly higher than the control. In Alfisol, there was no significant difference in Na values but in Ultisol, exchangeable Na was significantly increased by composts and NPK fertilizer applications. The interaction between variety and fertilizer did not have a significant effect on all measured parameters in Alfisol but it was significant for P, Ca, K and Na in Ultisol**.**

Discussion

The fruit yields of okra were significantly influenced by variety and applied amendments. The okra fruit yields from the plots with amendments differed significantly from the control. Previous studies by Akintomide and Osundare (2015)have shown that fertilizer application can significantly increase fruit production in okra by providing essential nutrients for plant growth, enhancing photosynthate synthesis and translocation, and increasing fruit weight. Compost application has also been found to promote root growth, nutrient uptake, plant stem height and dry weight (Soheli *et al*., 2012). Previous research has demonstrated that the quality of okra improves with increased organic fertilizer rates (Reeza and Azman, 2022). The application of compost significantly influenced soil chemical properties in both soils, leading to an increase in soil pH. This increase in pH may be attributed to the buffering capacity of compost, which contains higher concentrations of basic cations that raise pH levels (Arwenyo et al, 2023) When compost is added to acidic soil, it increases the soil pH and reduces the exchangeable acidity, aluminum, and iron, resulting in increased phosphorous availability and a high level of bioavailable labile phosphorous over time (Ch'ng et al., 2014). In the same study, it was also found that OC, total N, available P, exchangeable Na and Mg increased with fertilizer application compared to the control, with composts showing greater increases than NPK fertilizer. This may be attributed to microbial activity enhancing nutrient release from organic sources and the formation of organic matter; hence, an increase in soil organic matter was observed with the application of CPH-based compost. Compost also increased total and available P levels compared the control making soluble-P more readily available for plant uptake and influencing P binding dynamics in the soil.

The residual effect of CPH+PM+NL resulted in an increased okra fruit yield of 24 % and 30 % in Alfisol and Ultisol, respectively, compared to NPK plots Also, both CPH+PM and CPH+NL treatments produced significantly higher fruit yields than NPK and control plots in both soil types. Compost has been shown to supply plant nutrients in slowly available forms (Diacono and Montemurro, 2010), indicating that significant proportion of nutrients in the compost become available in the subsequent years. In contrast, nutrients from NPK fertilizer were depleted after first cropping, leaving behind less nutrients to sustain a good harvest in the second cropping. This is attributed to the quick nutrient release pattern of NPK and its high susceptibility to leaching loss (Fetzer et al, 2022).

The fertility study of the residual plots showed that the soil pH increased under CPH-based fertilizer compare to soil treated with NPK and the control in both soil types. This could be due to higher concentrations of basic cations in the organic materials, which raised pH levels and the continuous decomposition of the materials when added to the soil. Previous studies have reported increases in pH when organic fertilizers were applied (Akande *et al*., 2003; Eghball *et al.*, 2004; Ogunlade *et al.*, 2009). The higher accumulation of organic carbon at both locations in the plots treated with CPH-based compost than the control and NPK treated plots was expected because of the organic carbon contents of materials used for the composting. This aligns with the findings of Ajayi *et al*. (2007) and MoyinJesu (2007) that cocoa pod husk increased soil organic matter contents. Adequate residual N was not observed in the plot fertilized with NPK because much because a significant amount of the nitrogen in the inorganic fertilizer may have been lost to plant uptake and other pathways such as denitrification, ammonia volatilization and leaching. In contrast, application of CPH based compost increased the soil N content, and consistent with the findings of Kayode *et al.* (2018) that CPH-based fertilizer resulted in higher total N in the soil.

The available P contents were increased by CPH-based composts and NPK relative to the control at the end of the second cropping in Alfisol, although there was no significant difference between them. In Ultisol, CPH-based composts significantly increased the available P compared to NPK and the control, indicating the high level of P in the compost. The increase in P availability after organic manure application has also been reported by Gang and Bahl (2008).

The exchangeable K contents of the soil at both locations were significantly higher under CPH based-composts than NPK and the control. This could be attributed to the ability of CPH to release K and increase the organic matter contents of the soil (Adu-Dappah et al., 1994).The amount of residual K in the soil was closely related to the soil organic matter. By forming organic complexes with the organic substances present in the compost added to the soil, potassium mobility is reduced.

Conclusion

Recycling agricultural waste to produce compost is a safe method for crop cultivation. Previous studies on the use of organic materials have indicated that most of the organic wastes in the raw form are not suitable to apply directly to the soil due to low nutrient availability, environmental and economic implication. Composting is the most economical and environmentally safe way to utilize these useful natural resources. The study clearly demonstrates that using cocoa pod husk-based compost enhances okra production. Okra showed a positive response to compost application during both the first and second cropping seasons. The okra fruit yields from plots treated with CPH+PM+NL were significantly higher than those from NPK fertilizer and the control plot values in both the main and residual cropping seasons. This suggests that compost has the potential for build up residual nutrients in the soil over time. The better performance of compost-treated plants during the residual cropping period than NPK fertilizer can be attributed to the slow release of nutrients from CPH-based composts, while NPK fertilizer experiences quick release and leaching of nutrients at the beginning of planting period. Therefore, to achieve optimal okra performance, it is important to supplement soil nutrients with composts.

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