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Influence of Cocoa Pod Husk-Based Compost on Nutrient Uptake of Okra (*Abelmoschus esculentus* (L.) MOENCH) and soil properties on an Alfisol

Christianah Olubunmi Kayode[a], Gideon Olajiire Adeoye[b], Dorcas Tinuke Ezekiel-Adewoyin[c], Olufemi Emmanuel AyanfeOluwa[a], David Ogundeji Ogunleti[c], and Adenike Fisayo Adekunle[a]

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ABSTRACT

This experiment evaluated the potentials of cocoa pod husk (CPH)-based compost on okra and soil chemical properties. Three CPH-based compost: CPH+ Neem leaf (CPH+ NL), CPH+ Poultry manure (CPH+ PM) and CPH+ PM + NL were prepared. The treatments; 25, 50, 75, 100 kg N/ha of each compost and NPK mineral fertilizer at 40, 50, 60 kg N/ha and control, were applied to 5 kg soil each and arranged in a completely randomized design in three replicates. Two varieties of okra (NH47-4 and LD88) were grown for six weeks and residual effect evaluated. The Nitrogen, Phosphorus, and Potassium uptake of okra were determined. Pre- and post-cropping soil analyses were done. Data were analyzed using ANOVA and means separated by Duncan Multiple Range Test at $\alpha_{0.05.}$ The results showed that the nutrient uptake of okra consistently increased with CPH-based compost compared to control in both main and residual cropping. Nitrogen uptake ranged from 53.6 (60 kg N/ha NPK) to 106.7 (50 kg N/ha CPH+ PM) and 16.10 (50 kg N/ha NPK) to 55.06 (25 kg N/ha CPH + PM+ NL); Phosphorus uptake ranged from 6.9 (25 kg N/ha CPH+ NL) to 24.1 (60 kg N/ha NPK) and 3.70 (25 kg N/ha CPH+ NL) to 9.98 (50 kg N/ha CPH+ PM + NL), while potassium uptake ranged from 166.4 (25 kg N/ha CPH+ NL) to 244.48 (25 kg N/ha CPH+ PM+ NL) and 64.06 (40 kg N/ha NPK) to 122.29 (75 kg N/ha CPH+ NL) mg/plant in main and residual cropping, respectively. Organic carbon, pH, nitrogen (N), phosphorus (P), potassium (K), magnesium (Mg) and sodium (Na) were also significantly increased by the CPH-based compost. It could, therefore, be concluded that CPH-based compost could be a good fertilizer for okra production.

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Introduction

One of the most promising methods of improving soil fertility in intensified cropping systems is the use of compost from organic wastes (Adediran et al. 2003; Summer 2000). Composting offers the most sensible and economical way to avoid wastage of useful natural resources and at the same time produces high-quality soil amendment. Through composting, the undesirable features of waste materials (pathogens, odor) could be well managed. In general, finished compost is reduced in bulk (Adediran et al. 2006) and highly regarded for its ability to improve soil fertility and plant growth. Compost supply nutrients to the soil and their effects last longer than mineral fertilizers because they are slow releasers (Gabrielle et al. 2004; Shaikh and Patil 2013; Tu, Ristaino, and Hu 2006). Apart from their ability to release nutrients, compost is known to improve soil physical properties such as soil bulk density, water retention capacity, infiltration, and aeration (Adeyemo and Agele 2010; Deksissa, Short, and Allen 2008).

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Cocoa pod husk (CPH) is considered a waste, and vast quantity is being disposed daily as a result of ignorance of its efficacy as an organic fertilizer source. Though CPH is being used in the manufacturing of local black soap, the majority of the populace is oblivious of its ameliorating effects on nutrient-depleted soils. Cocoa pod husk is slow releasing relative to mineral fertilizers (Adeoye, Sridhar, and Ipinmoroti 2001) and it increased soil organic matter, soil total nitrogen (TN), available phosphorus (P), exchangeable cations (such as potassium (K) and calcium (Ca)) compared to mineral fertilizers (MoyinJesu 2003). Okra (*Abelmoschus esculentus*) is an important vegetable cultivated in the tropical regions mainly for its pod yield (Viscent, Michael and Stanley 2005). It is a fast-growing annual crop belonging to the family Malvaceae (Alege, Akinyele, and Bodunde 2009). It is an important vegetable crop throughout the tropics and sub-tropics (Akinyele and Osekita 2006; Hamon and Van Sloten 1989). The immature pods serve as ingredients of soup and stew (Osekita, Ariyo, and Kehinde 2000) and are eaten either fresh or cooked by boiling or frying. The fruit may also be dried and milled to powder for use as flavoring (Tindall 1983). Okra leaves can be eaten as a vegetable and the seeds can be a source of oil. Tindall (1983) reported that fruits of okra are rich in calcium, iron, protein, vitamin, and mineral elements needed for the development and maintenance of the human body. Positive response by okra to the application of mineral fertilizer has been well reported (Khetran et al. 2017; Viscent et al. 2005) but the problem is that this fertilizer is often scarce and too expensive beyond the reach of the local farmers. The solution then largely lies in organic fertilizers which are comparable to chemical fertilizers in yield improvement and consequently maintain the fertility of the soil (Akanbi 2001; Akande et al. 2006, 2010; Wang, Klassen, and Codallo 2009; Okutu and Ainika 2012). Research has shown that cocoa pod husk has been used on crops like cocoa, coffee, and maize (Ayeni 2010; MoyinJesu and Atoyosoye 2002; Ogunlade 2008) but there is little information on its use on fruit vegetables, which are major sources of vitamins and minerals in the human diet. This work, therefore, investigated the influence of cocoa pod husk-based compost on nutrient uptake of okra and soil properties in the screenhouse.

Materials and methods

Soil samples (0–15 cm) were collected, air-dried, sieved, and sub-sampled for nutrient analysis. Bulk sample was properly mixed to ensure homogeneity and 5 kg soil was weighed into each plastic pot. The soil is moderately acidic (pH of 6.2) and sandy loam in texture (Table 1). The total N (0.9 g/kg) was low as the value was below the critical level of 1.6–2.0 g/kg while the available P values (6 mg/kg) was also below the critical level of 7–20 mg/kg. The K status (0.4 cmol/kg) was marginal. The soil was low in organic carbon (9.4 g/kg) because it was below the critical level of 10–14 g/k g (FFD, 2012).

Table 1. Physical and Chemical properties of pre-cropping soil.

Parameters	Value
pH (H_20) (1:1)	6.2
Org C (g/kg)	9.4
Total N (g/kg)	0.9
Available P (mg/kg)	6
Exchangeable cations (cmol/kg)	
Ca^{++}	3.2
Mg^{++}	0.7
K^+	0.4
Na^+	0.2
Exchangeable acidity(Al^{3+} + H^+)	0.10
ECEC	4.60
Particle size (g/kg)	
Sand	686.0
Silt	104.8
Clay	209.2
Textural class	Sandy loam

Table 2. Nutrient contents of compost.

	Compost		
Nutrient (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

Three types of compost were prepared using cocoa pod husk (CPH), neem leaves (NL) and poultry manure (PM) in the following ratios by weight.

(i) CPH + NL + PM (3:1:1)
(ii) CPH + PM (3:1)
(iii) CPH + NL (3:1)

The treatments; 25, 50, 75, 100 kgN/ha of each compost and NPK mineral fertilizer at 40, 50, 60 kgN/ha and control, were applied to 5 kg soil each and arranged in a completely randomized design in three replicates. Two varieties of okra (NH47-4 and LD88) were used as test crop. There were 32 treatment combinations replicated three times to give 96 experimental units.

The CPH-based compost was applied two weeks before cropping by mixing thoroughly with the soil in each pot after which water was added. Each pot was placed on a saucer to collect leachates and poured back into the pot. Three seeds of okra were sown per pot but later thinned to two per pot. NPK fertilizer was applied one week after sowing. Supplementary watering was maintained throughout the growth period. At six (6) weeks after sowing (WAS) the plants were harvested by cutting at the soil surface in each pot. The roots were carefully removed and washed. Thereafter, roots and shoots were oven-dried to a constant weight and plant dry matter yield determined. After oven drying, the materials were milled and analyzed for N, P and K concentration. Nutrient uptake in the plant was calculated using the formula:

$$\text{Nutrient uptake} = \%\ \text{nutrient concentration} \times \text{dry matter yield (mg/plant)}$$

Residual effects of compost and mineral fertilizer on nutrient uptake of okra in the screenhouse were investigated. The soil in each pot was adequately watered, and okra varieties (NH47-4 and LD88) were re-seeded. The same methods used in the main cropping were employed, and data were subjected to statistical analysis using ANOVA and the means were separated by Duncan's Multiple Range Test (DMRT) at 5% probability level.

The CPH, NL, and PM were analyzed for total carbon (C), N, P, K, calcium (Ca) and Mg before composting. At maturity, samples were randomly taken from each compost type, milled and subjected to chemical analyses. The pH of the compost was determined in 1:2 sample water ratio using Electrometric method (IITA 1982). Organic carbon was determined by dry ashing method (Nelson and Sommers 1996). Total N was determined by the micro-Kjeldahl method (Bremner 1996). The samples were digested with perchloric and nitric acids; P was determined by vanadomolybdate yellow color procedure (Olsen and Dean 1965), K and sodium (Na) by flame photometer; Ca and Mg by Atomic Absorption Spectrophotometer.

The soil was air-dried and passed through a 2 mm sieve. Representative samples were taken and analyzed to determine the soil particle size, pH (H_2O), organic C, TN, available P as well as exchangeable K, Na, Ca and Mg.

Particle size analysis was determined using the Bouyoucos hydrometer method (Sheldrick and Hand Wang 1993). Soil pH was determined in distilled water at a 1:2 (w/v) soil to water ratio using Electrometric method (International Institute of Tropical Agriculture (IITA) 1982). Total N was determined using the micro-Kjedahl digestion method (Bremner 1996) while organic carbon was determined using dichromate wet oxidation procedure of Walkley and Black (Nelson and Sommers 1996). Available P was extracted using Bray-P1 method (International Institute of Tropical Agriculture (IITA) 1982) and determined colourimetrically following the procedure of Murphy and Riley (1962). Exchangeable K, Ca, Mg, and Na were extracted with 1.0 N (pH 7.0) 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). Exchangeable acidity was extracted with 1 N potassium chloride (KCl) (Thomas 1982) and determined by titration with 0.05 N sodium hydroxide (NaOH) using phenolphthalein as an indicator. The effective cation exchange capacity (ECEC) was calculated as the total sum of exchangeable bases and total exchangeable acidity.

Results

The soil is moderately acidic (with pH of 6.2) and sandy loam in texture (Table 1). The total N (0.9 g/kg) was low as the value was below the critical level of 1.6–2.0 g/kg while the available P values (6 mg/kg) was also below the critical level of 7–20 mg/kg (FFD 2012). The K status (0.4 cmol/kg) was higher than the critical level of 0.2 cmol/kg. The soil was low in organic carbon (9.4 g/kg) because it was below the critical level of 10–14 g/kg. The analysis of the compost used for the study is presented in Table 2.

The nutrient uptake of okra in the main cropping presented in Table 3 showed that the N, P, and K uptake of okra varieties was significantly ($p < 0.05$) different. Variety LD88 had the highest N, P and K uptake (87.66, 16.04 and 214.89 mg/plant, respectively), which were significantly higher than that of NH47-4 (67.20, 10.64, and 169.34 mg/plant, respectively). Among the fertilizer treatments, the highest N uptake (106.74 mg/plant) was obtained from plants treated with CPH+ PM at 50 kg N/ha which was not significantly different from plants treated with CPH+ NL at 50 kg N/ha (105.81 mg/plant), CPH+ PM at 75 kg N/ha (90.06 mg/plant), CPH+ PM+ NL at 50 and 75 kg N/ha (93.87 and 95.67 mg/plant, respectively) but was significantly higher than control (27.20 mg/plant) and other treatments. Phosphorus uptake values showed that NPK at 60 kg N/ha gave the highest value (24.14 mg/plant) which was not significantly different from CPH+ PM+ NL at 100 kg N/ha (18.76 mg/plant) but significantly ($p < 0.05$) higher than control (6.17 mg/plant) and other treatments. The highest K uptake (244.48 mg/plant) was obtained from plants treated with CPH+ NL at 50 kg N/ha, which was not significantly different from plants treated with CPH+ NL at 75 and 100 kg N/ha (227.05 and 226.82 mg/plant, respectively). It was also not significantly different from CPH + PM at 50 and 75 kg N/ha (229.42 and 214.78 mg/plant, respectively), CPH+ PM+ NL at 25 and 100 kg N/ha (220.82 and 219.82 mg/plant, respectively) but was significantly higher than all the other treatments and control (79.13 mg/plant). The interaction between the okra varieties and the fertilizer treatments on the N, P and K uptake was significant. The effects of CPH-based compost on soil chemical properties after the main cropping is shown in Table 4. The okra varieties had no significant effect on soil chemical properties in all the parameters measured except Mg. The highest pH (7.7) was recorded in soil treated with CPH+ PM applied at 50, 75, and 100 kg N/ha which was significantly higher than the values recorded in other fertilizer treatments and control (6.7). The organic carbon content increased from initial 9.4 g/kg to values between 9.6 and 12.7 g/kg for different rates of CPH-based compost. However, the organic carbon content in the NPK mineral fertilizer treated pots decreased to between 7.1 and 8.8 g/kg while the control treatment gave the least value of 7.0 g/kg. There was no significant difference among all the treatments in N content of the soil, although, CPH-based compost gave higher values (0.7–0.9 g/kg) than the control (0.6 g/kg). The highest P values of 6 mg/kg which were recorded from CPH+ PM at 75 kg N/ha and NPK at 50 kg N/ha was significantly higher than the other treatments. The control recorded the least P values (1 mg/kg). The soil K was enhanced significantly by the application of CPH+ PM at 25 and 50 kg N/ha (0.3 cmol/kg). The soil Ca was significantly enhanced by CPH-based compost treatments

Table 3. Nutrient uptake (mg/plant) of okra as influenced by applications of compost and NPK fertilizer during the main and residual cropping.

		Main			Residual		
Treatments		N	P	K	N	P	K
Variety							
NH47-4		67.20b	10.64b	169.34b	27.17	5.58	96.70
LD88		87.66a	16.04a	214.89a	28.52	6.12	88.86
		*	*	*	ns	ns	ns
Fertilizer	**Rate** (kg N/ha)						
Control	0	27.20h	6.17f	79.13g	11.62f	3.01f	45.80f
CPH+ NL	25	67.30defg	6.8bcde	166.38e	23.34cdef	3.70ef	83.13cde
	50	105.81a	16.08bc	220.82abc	24.89cde	7.45abc	102.04bcd
	75	79.91bcde	13.41bcde	227.05abc	24.38cde	5.22cdef	122.29ab
	100	80.14bcde	10.18cdef	226.82abc	23.10def	4.02def	95.89bcd
C PH+ PM	25	80.39bcde	14.66bcd	171.68e	35.80bc	5.44cdef	87.77cde
	50	106.74a	15.47bc	229.42ab	29.39cd	4.94cdef	95.68bcd
	75	90.06abc	16.23bc	214.78abcd	29.58cd	7.17abcd	98.38bcd
	100	82.00bcde	14.83bcd	210.08bcd	22.62def	6.24bcdef	91.60cde
CPH+ PM+ NL	25	93.87ab	13.26bcde	244.48a	55.06a	6.74bcde	133.60a
	50	84.91bcd	10.98cdef	197.51bcde	44.79ab	9.98a	89.28cde
	75	95.69ab	12.44bcdef	183.30de	41.33b	6.76bcde	107.59bcd
	100	64.08efg	18.76ab	219.82abc	39.97bc	8.91ab	111.69abc
NPK	40	72.35cdef	8.17def	124.80f	24.58cde	3.79ef	64.06ef
	50	54.78fg	11.89bcdef	164.30e	16.10ef	4.78cdef	78.65de
	60	53.61g	24.14a	193.47cde	19.99def	8.72ab	81.09de
V*F		*	*	*	*	*	*

ns: not significant; *: significant. Means with the 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

Table 4. Effects of CPH-based compost on soil chemical properties after the main cropping.

Treatment		pH(H_2O)	Org.C	N	P	Ca	Mg	K	Na
			(g/kg)		(mg/kg)		(cmol/kg)		
Variety									
NH47-4		7.3	7.6	0.8	5	2.3	3.0a	0.2	0.3
LD88		7.3	7.5	0.8	4	2.2	2.3b	0.2	0.3
		ns	ns	ns	ns	ns		ns	ns
Fertilizer	**Rate** (kg N/ha)								
Control	0	6.7g	7.0cd	0.6	1f	0.9c	1.0d	0.2b	0.2def
CPH+ NL	25	7.3c	9.9abc	0.7	2e	2.7ab	1.3c	0.2b	0.3bcd
	50	7.4bc	9.6abc	0.7	3d	2.8ab	1.8a	0.2b	0.3bcd
	75	7.3c	10.0abc	0.8	2e	2.9ab	1.4c	0.2b	0.3bcd
	100	7.2cd	12.3a	0.7	2e	2.7ab	1.6ab	0.2b	0.4ab
CPH+ PM	25	7.5b	8.8abc	0.7	3e	5.1a	1.6ab	0.3a	0.4ab
	50	7.7a	9.6abc	0.7	4c	4.0ab	1.5bc	0.3a	0.4ab
	75	7.7a	9.9abc	0.9	6a	4.6a	1.3c	0.2b	0.4ab
	100	7.7a	9.6abc	0.7	3d	3.7ab	1.6ab	0.2b	0.5a
CPH+ PM+ NL	25	6.9f	11.7ab	0.7	2e	3.6ab	1.2cd	0.2b	0.2def
	50	7.2cd	11.7ab	0.9	4c	3.7ab	1.3c	0.2b	0.3bcd
	75	7.4bc	12.7a	0.7	4c	5.0a	1.9a	0.2b	0.1f
	100	7.4bc	12.1a	0.8	5b	5.0a	1.4bc	0.2b	0.2def
NPK	40	7.1de	8.8bc	0.6	4c	0.8c	1.2cd	0.2b	0.2def
	50	7.0ef	8.7bc	0.6	6a	0.9c	1.1cd	0.2b	0.2def
	60	7.0f	7.1cd	0.9	5b	0.8c	1.3c	0.2b	0.3bcd
				ns					
V*F		*	ns	ns	*	ns	*	ns	ns

ns : not significant; *: significant.
Means with the 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

(2.7–5.1 cmol/kg) which were significantly higher than NPK fertilizer (0.8–0.9 cmol/kg) and control (0.9 cmol/kg). The compost treatments significantly enhanced the Mg values in the soil; CPH+ PM + NL at 75 kg N/ha recorded the highest Mg value of 1.9 cmol/kg which was significantly higher than the control (1.0 cmol/kg). The Na value of the soil was significantly enhanced by the compost treatments; CPH+ PM at 100 kg N/ha gave the highest Na value (0.5 cmol/kg) which was significantly not different from some of the compost treatments but significantly higher than NPK (0.2 cmol/kg) and control (0.2 cmol/kg). The interaction between varieties and fertilizers was significant on pH, P, and Mg but was not significant on N, K, Na, Ca, and organic carbon.

The nutrient uptake of okra in the residual cropping is presented in Table 3. There was no significant difference in the N, P, and K uptake between the varieties (Table 5). Fertilizer application significantly enhanced the uptake of N; CPH+ PM+ NL applied at 25 kg N/ha had the highest N uptake (55.06 mg/plant) which was significantly higher than NPK (16.10–24.58 mg/plant) and control (11.62 mg/plant) which had the least N uptake value. The CPH+ PM+ NL at 50 kg N/ha gave the highest P uptake (9.98 mg/plant) which was not significantly different from CPH+ PM+ NL at 100 kg N/ha (8.91 mg/plant), NPK at 60 kg N/ha (8.72 mg/plant) and CPH + PM at 75 kg N/ha (7.17 mg/plant) but significantly ($p < 0.05$) higher than other treatments and the control (3.01 mg/plant). In terms of K uptake, CPH+ PM+ NL at 25 kg N/ha gave the highest value (133.60 mg/plant) which was not significantly different from CPH+ NL at 75 kg N/ha (122.29 mg/plant) and CPH+ PM+ NL at 100 kg N/ha (111.69 mg/plant) but significantly higher than NPK (64.06–81.09 mg/plant) and the control (45.80 mg/plant). The interaction between variety and fertilizer treatment was significant on N, P, and K uptake. The effect of CPH-based compost treatments on soil chemical properties after residual cropping is presented in Table 5. The effect of variety was not significant on pH, Na, Mg, Ca, and Org. C but was significant on N, P and K. The soil on which NH47-4 was grown had more P (6 mg/kg) and K (0.2 cmol/kg), however, the soil with LD88 had more N (0.3 g/kg). The effect of fertilizer application was significant on all the chemical properties of soil considered. The pH of the soil was significantly enhanced with CPH-based compost treatments (7.0–7.3) compared to NPK (6.8–6.9) and control

Table 5. Chemical properties of soil as influenced by CPH-based compost and NPK fertilizer after the residual cropping.

Treatment		pH (H_20)	Org. C	N	P	Ca	Mg	K	Na
			(g/kg)		(mg/kg)		(cmol/kg)		
Variety									
NH47-4		7.1	9.9	0.2b	6a	2.8	1.1	0.2a	0.5
LD88		7.1	9.5	0.3a	5b	2.6	1.1	0.1b	0.5
		ns	ns			ns	ns		ns
Fertilizer	**Rate** (kg N/ha)								
Control	0	6.8f	7.3fg	0.2e	4cd	2.1e	0.9efg	0.1b	0.4c
CPH+ NL	25	7.0cd	8.2ef	0.2e	5bc	2.3cde	1.1cde	0.2a	0.5b
	50	7.2ab	9.3de	0.3b	4cd	2.7bcde	0.7g	0.2a	0.5b
	75	7.0cd	11.0bc	0.2e	5bc	2.9bc	1.6a	0.2a	0.5b
	100	7.2ab	8.9e	0.2e	4cd	2.3cde	1.0def	0.1b	0.6a
CPH+ PM	25	7.1bc	12.5ab	0.4a	6ab	2.2de	1.3bc	0.2a	0.5b
	50	7.2ab	11.3bc	0.4a	5bc	2.5bcde	1.2bcd	0.2a	0.5b
	75	7.1bc	10.1cd	0.2e	6ab	2.9bc	0.7g	0.1b	0.5b
	100	7.0cd	8.6e	0.2e	5bc	2.7bcde	0.8g	0.1b	0.6a
CPH+ PM+ NL	25	7.2ab	12.3ab	0.3b	4cd	3.5a	1.4b	0.1b	0.6a
	50	7.2ab	12.7a	0.2e	5bc	2.5bcde	1.2bcd	0.2a	0.5b
	75	7.3a	12.1ab	0.3b	7a	2.6bcde	1.2bcd	0.2a	0.6a
	100	7.2ab	11.9ab	0.2e	7a	3.1ab	1.6a	0.2a	0.5b
NPK	40	6.9e	6.1g	0.1f	5bc	2.8bcd	1.1cde	0.1b	0.5bd
	50	6.8f	6.5g	0.2e	5bc	3.7a	0.9efg	0.1b	0.5b
	60	6.9e	7.0fg	0.1f	5bc	2.3cde	1.3bc	0.1b	0.5b
V*F		*	*	*	*	*	*	*	*

ns: not significant; *: significant. Means with the 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.

(6.8). The Org. C content of the soil was significantly influenced by the application of the compost treatments (8.6–12.7 g/kg) compared to control (7.3 g/kg) and NPK (6.1–7.0 g/kg). In terms of N content; CPH+ PM applied at 25 and 50 kg N/ha recorded the highest N values of 0.4 g/kg each which was significantly higher than all the other compost treatments, NPK, and control (0.2 g/kg). Application of compost resulted in significant increase in P content of soil compared with NPK and control; CPH+ PM+ NL applied at 75 and 100 kg N/ha recorded the highest value of P (7 mg/kg each) which was significantly ($p < 0.05$) higher than the control (4 mg/kg) and other treatments. The highest Ca (3.5 cmol/kg) was recorded from soil treated with CPH+ PM+ NL at 25 kg N/ha which was significantly ($p < 0.05$) higher than control (2.1 cmol/kg) and some of the compost treated soil. Magnesium content of soils was significantly enhanced by CPH-based compost; CPH+ PM+ NL at 100 kg N/ha and CPH+ NL at 75 kg N/ha recorded the highest Mg values of 1.6 and 1.6 cmol/kg respectively; these values were significantly higher than the other compost treated soils, NPK, and control (0.9 cmol/kg). CPH-based compost significantly increased the K content of soil compared to NPK and control which recorded the lowest K value.

Application of CPH-based compost significantly enhanced the exchangeable Na; CPH+ PM+ NL applied at 25 kg N/ha and CPH+ NL at 100 kg N/ha recorded the highest exchangeable Na value of 0.6 and 0.6 cmol/kg which was significantly higher than NPK and control (0.5 and 0.4 cmol/kg, respectively) which recorded the least value.

Discussion

The LD88 variety of okra performing better than NH47-4 in N, P, and K uptake suggests that the LD88 has a higher genetic potential to tap nutrients better than NH47-4. This is in line with the submission of Iyagba, Onuegbu, and Ibe (2012), Omotoso and Johnson (2015) and Solangi (2015) that variety influence okra performance. However, the finding is contrary to the report of Gudugi (2013) where there was no significant difference between LD88 and NH47-4. The differences in the results may be alluded to differences in the materials used and/or environmental factors. The findings further revealed that the uptake of N, P, and K were higher with the application of compost and least with control plants indicating the necessity of nutrients for okra growth (Kwayep et al. 2017). This suggests that the N, P, and K in the applied compost were available for okra uptake during the growth period. This is in agreement with the findings of Abd El-Kader, Shaaban, and Abd El-Fattah (2010) and Pushpava, Arulthasan and Kandaswamy (2014) that the application of compost improved N, P and K uptake of okra.

The significant interaction observed between the varieties and fertilizer indicated that the performance of the variety was fertilizer based. The result could be different if other okra varieties were used. However, the result is contrary to the report of Gudugi (2013) where the interaction between varieties and fertilizer was significant. This may also be due to differences in the materials used and/or environmental factors. The better performance of compost treated plant over NPK fertilizer at residual cropping showed that compost can support the growth of crop for more than one season. This is in agreement with the findings of AdeOluwa and AyanfeOluwa (2015) as well as AyanfeOluwa, AdeOluwa, and Aduramigba-Modupe (2015) that cocoa pod husk and other compost are slow releasing than mineral fertilizer.

The soil pH at the end of the residual cropping increased above the initial value across the compost treatments. The higher soil pH in soil treated with CPH based compost than NPK and control could be as a result of buffering effect of the compost. This confirmed the earlier findings (Adeoye, Sridhar, and Ipinmoroti 2001; Akande et al. 2003; Kayode et al. 2013; Ogunlade 2008; Ogunwole et al. 2012) that application of organic materials ameliorated acidic tropical soils and thereby improve crop production. The CPH-based compost enabled higher build-up of organic carbon and increased total N in the soil. Particularly, the CPH+ PM+ NL to the greatest extent enhanced release of essential N, P, and K. This is in agreement with the findings of MoyinJesu (2007) and Ogunlade, Oluyole, and Aikpokpodion (2009) that cocoa pod husk increased soil organic matter and total N.

Cocoa pod husk-based compost improving soil available P indicated that P was released from the organic amendments. This is in agreement with the work of MoyinJesu (2007) that cocoa pod husk increased available P. The soil K, Ca, and Mg were increased by the application of CPH-compost and NPK relative to the control.

Conclusion

There was a positive response by okra to CPH-based compost application in both main and residual cropping. The residual effect of the compost on okra nutrient uptake was significantly higher those of NPK and control treatments. This suggests that the CPH-based compost have the potential to make nutrients available for okra production.

References

Abd El-Kader, A. A., S. M. Shaaban, and M. S. Abd El-Fattah. 2010. Effect of irrigation levels and organic compost on okra plants (*Abelmoschus esculentus* L.) grown in sandy calcareous soil. *Agriculture and Biology Journal of North America* 1 (3):225–31. doi:10.5251/abjna.2010.1.3.225.231.

Adediran, J. A., L. B. Taiwo, M. O. Akande, and B. O. Lawal. 2006. *Working manual on compost making and use*. In *A guideline for extension agents, farmers, compost makers and users*, Eds G. O. Adeoye, and T. A. Akinlosotu, 21pp. Institute of Agricultural Research and Training, Obafemi Awolowo University, Ibadan printing press. ISBN 978-070-108-7

Adediran, J. A., N. De Bacts, P. N. S. Mnkeni, L. Kiekens, N. Y. O. Muyima, and A. Thys. 2003. Organic waste materials for soil fertility improvement in the Border region of the Eastern Cape, South Africa. *Biological Agriculture and Horticulture* 20:283–300. doi:10.1080/01448765.2003.9754974.

AdeOluwa, O. O., and O. E. AyanfeOluwa. 2015. Cocoa pod husk and rice husk ash options as organic potassium fertilizers for okra (*Abelmoschus esculentus* L. Moench) production. *Ibadan Journal of Agricultural Research* 10:128–38.

Adeoye, G. O., M. K. C. Sridhar, and R. R. Ipinmoroti. 2001. Potassium recovery from farm waste for crop growth. *Soil Science and Plant Analysis* 32 (16):2347–58. doi:10.1081/CSS-120000377.

Adeyemo, A. J., and S. O. Agele. 2010. Effects of tillage and manure application on soil physicochemical properties and yield of maize grown on a degraded intensively tilled Alfisol in southwestern Nigeria. *Journal of Soil Science and Environmental Management* 1 (8):205–16.

Akanbi, W. B., 2001. Growth, nutrient uptake and yield of maize and okra as influenced by compost and nitrogen fertilizer under different cropping systems. PhD. Thesis. University of Ibadan, Department of Agronomy, Ibadan, Nigeria. p.207

Akande, M. O., F. I. Oluwatoyinbo, C. O. Kayode, and F. A. Olowookere. 2006. Response of maize (*Zea mays*) and okra (*Abelmoshus esculentus*) intercropped relay with cowpea (*Vigna unguiculata*) to different levels of cowdung amended phosphate rock. *World Journal of Agricultural Sciences* 2 (1):119–22.

Akande, M. O., F. I. Oluwatoyinbo, E. A. Makinde, E. S. Adepoju, and I. S. Adepoju. 2010. Response of okra to organic and inorganic fertilization. *Nature and Science* 8 (11):261–66.

Akande, M. O., F. I. Oluwatoyinbo, J. A. Adediran, K. W. Busari, and I. O. Yusuf. 2003. Soil amendments affect the release of P from rock phosphate and the development and yield of okra. *Journal of Vegetable Production* 9 (2):3–9. doi:10.1300/J068v09n02_02.

Akinyele, B. O., and O. S. Osekita. 2006. Correlation and path coefficient analyses of seed yield attributes in okra (*Abelmoschus esculentus* (L.) Moench). *African Journal of Biotechnology* 5 (14):1330–36.

Alege, G. O., B. O. Akinyele, and M. O. Bodunde. 2009. Effect of nutrient source on the phenotypic expression and gall formation of okra (*Abelmoschus esculentus* (L.) Moench). *Applied Tropical Agriculture* 14 (1):54–59.

AyanfeOluwa, O. E., O. O. AdeOluwa, and V. O. Aduramigba-Modupe. 2015. Residual fertilizer value of OBD-plus compost for maize (*Zea mays*) production. *International Journal of Plant and Soil Science* 6 (3):162–67. doi:10.9734/IJPSS/2015/15742.

Ayeni, L. S. 2010. Effect of combined cocoa pod ash and NPK fertilizer on soil properties, nutrient uptake and yield of maize (*Zea mays*). *Journal of American Science* 6 (3):79–83.

Bremner, J. S. 1996. Nitrogen-total. *Method of Soil Analysis*. Sparks D. I. Ed. 2nd ed. Book Series No 5, Madison, Wisconsin. In *Soil Science Society of America*, 1085–121.

Deksissa, T., I. Short, and J. Allen, 2008. Effect of soil amendment with compost on growth and water use efficiency of Amaranth. In: *Proceedings of the UCOWR/NIWR Annual Conference*: International water resources challenges for the 21st century and water resources education, July 22-24. Durham, NC.

Federal Fertilizer Department (FFD). 2012. Fertilizer use and Management Practices for crops in Nigeria. *Published by the Federal Ministry of Agriculture and Rural Development (FMARD)*. V. O. Chude, S. O. Olayiwola, C. Daodu, and 4. Ekeoma. Eds. Abuja. Chapter 1:40-41

Gabrielle, B., J. Da-Silveira, S. Hovot, and C. Francou. 2004. Simulating urban compost waste effects on carbon and nitrogen dynamics using biochemical index. *Journal of Environmental Quality* 33:2333–42.

Gudugi, I. A. S. 2013. Effect of cow dung and variety on the growth and yield of Okra (Abelmoschus esculentus (L.). *European Journal of Experimental Biology* 3 (2):495–98.

Hamon, S., and D. H. Van Sloten. 1989. Characterization and evaluation of okra. In *The use of plant genetic resources*, Eds A. D. H. Brow, and O. Frankel, 173–96. Cambridge: Cambridge University Press.

Hendershot, W. H., and H. Lalande. 1993. Ion exchange and exchangeable cations. In *Soil sampling and methods of analysis*, Ed. M. R. Carter., Vol. 19, 167–76. London: Lewis Publishers.

International Institute of Tropical Agriculture (IITA). 1982. *Selected methods for soil analysis*. Ibadan, Nigeria: International Institute of Tropical Agriculture. I.I.T.A. series, No 7 53–56.

Iyagba, A. G., B. A. Onuegbu, and A. E. Ibe. 2012. Growth and Yield Response of Okra (Abelmoschus esculentus (L.) Moench) Varieties to Weed Interference in South-Eastern. *Global Journal of Science Frontier Research Agriculture and Veterinary Sciences* 12 (7):22–31.

Kayode, C. O., M. O. Akande, A. F. Adekunle, D. O. Ogunleti, and G. O. Adeoye. 2013. Effect of cocoa pod husk based compost on the growth, nutrient uptake and dry matter yield of Roselle. *Nigerian Journal of Soil Science* 23 (1):136–42.

Khetran, R., M. Afzal Kasi, J. Ali, S. Zulfiqar Ali, M. Basharat, S. Fahmid, N. Ali, and A. Raza. 2017. Effect of different doses of NPK fertilizers on seed yield of okra (*Abelmoschus esculentus* (L) Moench). *International Journal of Advanced Research in Biological Sciences* 4 (1):163–72.

Kwayep, L. N., C. Suh, C. Konje, A. Manga, T. Kenfo, V. Lombeko, and S. H. Djomo. 2017. Effects of different soil amendments on the performance of okra (Abelmoschus esculentus L.) in a bimodal rainforest zone. *African Journal of Agricultural Research* 12 (24):2056–62. doi:10.5897/AJAR.

MoyinJesu, E. I. 2003. Incorporation of industrial biomass and their effect on growth, nutrient content of four successive crops of amaranthus. *Partanika Journal of Tropical Agricultural Science* 26:49–58.

MoyinJesu, E. I. 2007. Use of selected agro industrial biomass for enhancing seed, nitrogen, ash and crude protein quality of Amaranthus. *Emirate Journal of Food and Agriculture* 19 (1):13–21. doi:10.9755/ejfa.v12i1.5142.

MoyinJesu, E. I., and B. Atoyosoye. 2002. Utilization of agricultural waste for the growth, leaf and soil chemical composition of cocoa seedlings in the nursery. *Pertanika Journal of Tropical Agricultural Science* 25 (1):53–62.

Murphy, J., and J. P. Riley. 1962. A modified single solution method for determination of phosphate in natural waters. *Anal. Chim. Acta* 27:31–36.

Nelson, D. W., and L. E. Sommers. 1996. Total carbon, organic carbon and organic matter. *Method of soil analysis*: Sparks, D. L. Ed. 2nd ed. Book Series No.5. Madison. In *Soil Science Society of America*, 961–1010.

Ogunlade, M. O., 2008. Potentials of neem-fortified cocoa pod husk on cocoa seedling establishment in old cocoa plantation in Alfisol and Owena, South-West Nigeria. PhD. diss., University of Ibadan.

Ogunlade, M. O., K. O. Oluyole, and P. O. Aikpokpodion. 2009. An evaluation of the level of fertilizer utilization for cocoa production in Nigeria. *Journal of Human Ecology* 25 (3):175–78. doi:10.1080/09709274.2009.11906152.

Ogunwole, O. M., G. O. Adeoye, O. Fagbola, and J. S. Ogeh. 2012. Studies on nutrient release pattern of neem fortified cocoa pod husk fertilizer in an Alfisol. *Journal of Tropical Soils* 17 (2):129–34.

Okutu, P. C., and J. N. Ainika. 2012. Productivity of Okra (*Abelmoshus esculentus*) in response to rate and method of cattle manure application in the northern guinea savannah of Nigeria. *International Journal of Organic Research and Development* 5:114–26.

Olsen, S. R., and L. A. Dean. 1965. Phosphorus. *Method of soil analysis*. 2nd ed. Agronomy 9. Madison, Wisconsin. In *Soil Science Society of America*, 1035–49.

Omotoso, S. O., and O. Y. Johnson. 2015. Growth and Yield of Two Varieties of Okra (Abelmoschus esculentus (L). Moench) as affected by Potassium Fertilizer Sources. *Journal of Biology, Agriculture and Healthcare* 5 (8):2224–3208.

Osekita, O. S., O. J. Ariyo, and O. B. Kehinde. 2000. Variation and inter – Character association in segregating F3 populations arising from two crosses of okra (*Abelmoschus esculentus* (L.) Moench). *Moor Journal of Agricultural Resources* 1:32–36.

Pushpavalli, R., T. Arulthasan, and K. G. Kandaswamy. 2014. Growth, nutrient uptake and yield of Okra (*Abelmoschus esculentus* (L) Moench) as influenced by organic and inorganic K fertilizers. *Academic Journal of Agricultural Research* 2 (10):203–06.

Shaikh, S., and M. Patil. 2013. Production and utilization strategies of organic fertilizers for organic farming: An ecofriendly approach. *International Journal of Life Science and Pharma Research* 3 (2):1–5.

Sheldrick, B., and C. Hand Wang. 1993. Particle- size distribution. In *Soil sampling and methods of analysis*, Ed M. R. Carter, 499–511. Canadian Society of Soil Science: Lewis Publishers, USA.

Solangi, M., A. A. Tagar, A. M. Solangi, A. G. Siyal, R. K. Soothar, and A. R. Shah. 2015. Nutrient uptake of some okra varieties as influenced by different levels of applied N, P and K. *Science International* 27 (5):4327–31.

Summer, M. T. 2000. Beneficial use of effluents, wastes and biosolids. *Communication in Soil Science and Plant Analysis* 31:1701–15. doi:10.1080/00103620009370532.

Thomas, G. W. 1982. Exchangeable cations. *Methods of soil analysis. part 2*. Agronomy Monogram 9. A. L. Page, R. H. Miller and D. R. Keeney Eds. Madison. In *Soil Science Society of America*, 159–65.

Tindall, H. D. 1983. *Vegetable in the Tropics*, 36–47. London: Macmillan Press Ltd.

Tu, C., J. B. Ristaino, and S. Hu. 2006. Soil microbial biomass and activity in organic tomato farming system: Effects of organic inputs and surface mulching. *Soil Biological Biochain* 38:247–55. doi:10.1016/j.soilbio.2005.05.002.

Vinscent, B. O., T. M. Michael, and M. M. Stanley. 2005. Effect of cattle manure application on yield and yield indices of okra (*Abelmoschus esculentus* L. Moench). *Journal of Agriculture and Environment* 3:125–29.

Wang, Q., W. Klassen, and M. Codallo. 2009. Cover crops and organic mulch to improve tomato yields and soil fertility. *Agronomy Journal* 101:345–51. doi:10.2134/agronj2008.0103.