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EVALUATION OF SOIL CHEMICAL PROPERTIES AND CARROT PERFORMANCE AS INFLUENCED BY INTEGRATED APPLICATION OF POULTRY MANURE AND COCOA POD HUSK IN THE RAINFOREST AGROECOLOGICAL ZONE OF NIGERIA

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ABSTRACT

The high cost of inorganic fertilizer, difficulties involved in its use, its scarcity, coupled with its adverse effects associated with its continuous use on soil quality prompted the need to research into cheap, locally available organic materials to combat soil fertility problems. Field experiments were conducted in 2019 and 2020 to evaluate the effects of the integrated application of poultry manure (PM) and cocoa pod husk (CPH) on soil chemical properties, growth, leaf nutrients content and yield of carrot at Igba in the rainforest ecology of southwest Nigeria. The treatments consisted of PM and CPH each at three levels (0, 5, 10 t ha^{-1}) in a 2 x 3 factorial experiment laid into randomized complete block design with three replicates. Data were collected on soil chemical properties, growth parameters, leaf nutrients content and yield parameters. Data collected were subjected to analysis of variance using Statistical Analysis System Institute Package (SAS, 2000). The soil was slightly acidic (pH 5.5.), low in nitrogen (0.12g kg), available phosphorus (8 mg kg^{-1}). Integrated application of PM and CPH significantly ($P \leq 0.05$) improved soil pH, organic carbon, total N, available P, exchangeable bases and lowered exchangeable acidity. Plots with integrated application of PM and CPH had higher values of soil pH, exchangeable bases, ECEC, total N, total organic carbon, available P and lower values of exchangeable acidity and micronutrients than the plots with their sole applications. There were reductions in soil pH, exchangeable bases, ECEC, total N and organic carbon in the control plots in the second cropping seasons. Growth parameters were better enhanced in plots with the integrated application of PM and CPH than either of their sole. There were significant improvements in plant height, leaf length and shoot diameter in the second cropping season in plots amended with PM, CPH and their integrations as against control plots where reductions in the growth characteristics were obtained. The leaf content of N, P, K and Ca were significantly ($P \leq 0.05$) enhanced in plots with integrated application of PM and CPH than the plots with their sole application. Carrot root yield characteristics were significantly ($P \leq 0.05$) enhanced in plots with the integrated application of PM and CPH than plots with the sole application of PM or CPH. Root yield was increased in the second cropping season in plots treated with the sole application of PM, CPH and their integrations, while there were reductions in root yield parameters in the control plots. Improvements in soil nutrients status, growth, leaf nutrients content and root yield of carrot in both cropping season in the amended plots when compared to the control plots, imply that integrated use of PM and CPH could be used in the enhancement of production of carrot on sustainable basis in the study area.

Key Words: Poultry manure; cocoa pod husk; carrot; integrated application; sole application.

INTRODUCTION

Carrot (*Daucus carota*) is a cool-season crop grown worldwide (Vilela, 2004). In Nigeria and other West African countries, carrot cultivation has been widely practiced. Carrot is largely cultivated in the northern part of Nigeria in area such as Zaria, Sokoto, Kano and Jos, particularly during the dry season when temperatures are favourably low, and the crop is least affected by pests and diseases (Ahmed *et al*., 2014). Carrot yields are generally low in Nigeria compared with the yield from Europe and elsewhere. In Nigeria, Sarkindiya and Yakubu (2006) obtained a carrot yield of 14-23 t ha^{-1} as against a reported yield of 30-60 t ha^{-1} in Europe (WCM, 2013). Carrots are medium feeders; hence, they require fertile soil which allows rapid, uninterrupted growth (Wafaa, 2013). The increasing population in Nigeria has brought about pressure on the limited soil resources through shortening of the length of fallow period which has resulted in the rapid loss of soil fertility, increasing soil acidity and low crop yield (Adeoye *et al.,* 2008). Attempts to boost crop yield in Nigeria, led to the use of inorganic fertilizer which significantly increased their crop yield on immediate basis, but later discovered to reduce crop yield because of the degradation effect on the soil physical and chemical properties caused by the continuous use of chemical fertilizers (Ojeniyi, 2002). In addition, the use of inorganic fertilizer in Nigeria is low due to high cost, scarcity, poorly developed infrastructure for fertilizer distribution, marketing and ignorance of the peasant farmers about the correct usage of fertilizer (Adeleye and Ayeni, 2009). Therefore, there is a need to investigate cheap, locally available organic materials to combat soil fertility problems.

Cocoa pod husk is used by African farmers as a biofertilizer. In Ghana, the ash of cocoa pod husk was successfully tried as fertilizer for maize production (Adu-dapaah *et al*., 1994). Cocoa pod husk derived fertilizer increases N, P, K, Ca, Mg, micronutrients, and the pH status of soil and its correct application can thus partially or entirely substitute the use of inorganic fertilizer (Ayeni, 2010). In Nigeria, huge amount of poultry manure is generated and heaped on dumpsites. Incorporating poultry manure into the soil for crop production will be beneficial since most Nigerian soils are low in organic matter, which is crucial for maintaining soil fertility. Several research studies conducted on the effect of animal manures on soil productivity indicate positive effects. For instance, the application of animal manure increased the cation exchange capacity (CEC) of soils, thus exhibiting greater nutrient retention capacity of the soil (Mbah and Mbagwu, 2006).

In southwest Nigeria, very little work has been reported regarding the effect of different organic wastes on vegetable crops particularly carrot. Few studies conducted on the response of carrots to inorganic fertilizer were mainly centered on the inorganic nitrogenous fertilizer in northern Nigeria (Ahmed *et al*., 2014). However, studies on the integrated use of organic manures on carrots is very scanty, particularly in the southwest region that belongs mainly to rainforest agroecological zone of Nigeria. Considering the advantages of carrot production compared with other vegetables; its increasing appeal for human consumption and its less availability due to the Boko Haram and Bandits crises that have displaced most carrot farmers in northern Nigeria, it has become apparent that research interest is focused on its production in the rainforest agroecological zone of Nigeria. This study aimed at evaluating the potential of poultry manure and cocoa pod husk when they are combined in the enhancement of soil fertility and carrot production in the rainforest agroecological zone of Nigeria.

MATERIALS AND METHODS

Description of the Site

The field experiments were carried out in 2019 and 2020 in Igba village (Latitude 07^0 07^1N, Longitude 04^0 52^1E) in the rainforest zone of the southwest Nigeria. The mean annual rainfall is about 1670 mm precipitated in 220 -270 days (Mid-March – Mid-November). It enjoys a bimodal rainfall pattern with early rain occurring between March to July and late rain between August to October with five (5) months of dry season. The mean relative humidity is about 69 %, the sunshine hours varied from 2.5 to 7 hours and appeared lowest in July, August and September. The mean monthly temperature at the site is 27^0C (Federal Department of Aviation, Climatological Station, Akure (FDACSA, 2020). The soil is sandy in texture and slightly acidic pH 5.5 and classified as Oxic Tropuldalf (Alfisol) derived from quart, gneiss and Schist (Akinbola *et al.,* 2009). The site is located in the lowland rainforest agroecological zone of Nigeria with a semi deciduous vegetation. The site has been previously cultivated to arable crops such as cassava and cocoyam and it has been under fallow for two years prior to the commencement of the field experiment.

Treatments and Experimental Design

The treatments involved two factors, poultry manure (PM) and cocoa pod husk (CPH) each at three levels (0, 5 and 10 t ha^{-1}). The two factors were investigated in a 2 x 3 factorial to produce nine (9) treatment combinations arranged in randomized complete block design with each treatment replicated three times. Twenty seven (27) plots of 1 m by 1 m each were maintained at each planting season. The same plot of land was used for the two planting seasons but no treatment was applied at the second planting season. A total land area of 14 m by 5 m was marked out for the experiment, the site was manually cleared, packed and divided into three (3) blocks and each block was demarcated by 0.5 m wide alleyways. Each block was further divided into nine (9) plots of 1 m by 1 m and each plot was demarcated by 0.5 m wide alleyway. The plots were made into 27 raised beds of 1 m x 1 m each with a traditional hoe. The raised beds were thoroughly pulverized and raked free of stones to allow good root development. Dried and ground PM and CPH were uniformly spread on the plots and incorporated into the soil with a hand-hoe three days after land preparation. Carrot seeds (Thema variety) were sown directly to the prepared beds a week after organic manure application by drilling in rows spaced at 20 cm apart, which were later thinned three weeks after the emergence of carrot seedlings to attain spacing of 20 cm apart. Weeding and other cultural operations were the same for all the treatments and were attended to regularly.

Soil Analysis

Prior to the commencement of the field experiment, surface core samples (0-15 cm) were randomly collected from the experimental site using soil auger, bulked, air-dried and sieved using 2 mm mesh and processed for routine chemical analysis of the initial soil characteristics. At the end of each cropping seasons, another set of soil samples (0 – 15 cm) were collected on treatments basis and per replicate and processed for chemical analysis. Soil pH was determined at 1:2 soil water ratio using a glass electrode pH meter. Organic carbon was determined by dichromate oxidation method, total nitrogen by kjeldahl digestion and technicon auto analyzer, and exchangeable cations by a normal NH_4OAC extraction. Calcium, magnesium and manganese were determined by atomic absorption spectrophotometry. Cation exchange capacity was determined by the summation of NH_4OAC-extractable cations plus 1.0 N KCl extractable acidity.

Poultry Manure and Cocoa Pod Husk Analysis

Nutrients composition of powedered PM and CPH were determined after ashing in the muffle furnace. Total N by kjeldahl method and for other nutrients, PM and CPH were subjected to wet digestion using 25ml of HNO_3. The filtrate in the digest was used for nutrient determination (AOAC, 2000).

Growth and Yield Analysis

Ten (10) carrot stands were randomly selected per plot and tagged for the estimation of growth and yield parameters. Leaf length, number of leaf, plant height were measured at 80 days after sowing of carrot seeds. Leaf length was measured using a meter rule, plant height was measured in cm from the ground level to the top of the shoot using a meter rule, while the leaves were counted. Shoot fresh weight was determined using a weighing balance and the shoot dry weight was determined by oven drying 10 stands per plot to constant weight at 65^0C. Root fresh weight was determined using a weighing balance in g per stand. Root diameter was measured at the widest middle portion of the root using vernier caliper. The number of forked, cracked and rotten roots were counted separately on treatments basis as malformed roots and percentage was calculated from the number of total harvested roots. Root dry weight was determined by oven drying roots to constant weight at 65^0C. Marketable root yield was determined by counting roots with no deformities like cracks, forking, malformation and without spots in relation to the total number of roots harvested.

Leaf Nutrients Analysis

At harvest, matured leaves were collected from five (5) stands per plot, washed in water and oven-dried at 65^0C for 48 hours and ground for routine chemical analysis. The nutrients in the ash were then brought into solution by the addition of 10 % HCl. Leaf N was determined using kjeldahl digestion method. phosphorus was determined colourimetrically by the vanadomolybdate method, K by flame photometer, Ca and Mg were determined by AAS (AOAC, 2000).

Data Analysis

Data on soil chemical properties, leaf nutrients content, growth and yield parameters were subjected to analysis of variance using Statistical Analysis System Institute Package-General Linear Model (SAS, 2000). Means were compared using New Duncan's Multiple Range Test at 5% level of significance were F-ratio is found to be significant.

RESULTS

Table 1 shows the initial physical and chemical properties of the soil of the experimental site before land preparation. The soil was sandy in texture, slightly acidic, low in total nitrogen, available phosphorus, organic carbon, effective cation exchange capacity (ECEC), exchangeable magnesium (Mg), exchangeable potassium (K), and exchangeable calcium (Ca). The micronutrients such as iron (Fe), copper (Cu), manganese (Mn) and zinc (Zn) were high when compared to the established critical levels of nutrients for arable crops in southwest Nigeria. The established critical level of nutrients are - organic carbon 30 g kg^{-1}, total N 1.5 g kg^{-1}, available p 10-15 mg k g^{-1}, K 0.45 cmol kg^{-1}, Mg 0.30 cmol kg^{-1}, Ca 2.5 cmol kg^{-1}, Fe 45-10 mg kg^{-1}, Zn 0.2-1.0 mg kg^{-1}, Mn 0.0 – 5.0 mg kg^{-1} and Cu 0.2-1.0 mg kg^{-1} (Adeoye and Agbbola, 1985).

The nutrient composition of poultry manure (PM) and cocoa pod husk (CPH) used in the field experiment are shown in Table 2. The PM and CPH contained a high concentration of organic carbon, total nitrogen, phosphorus, potassium, calcium and magnesium. Also, PM and CPH had a low concentration of micronutrients (Zn, Cu, Fe and Mn). The PM had a higher concentration of the essential macronutrients except K than CPH.

Table 1: Initial Soil Physical and Chemical Properties of the experimental Site

Physical Properties	**Value**
Sand (g kg^{-1})	942
Silt (g kg^{-1})	15
Clay (g kg^{-1})	42
Textural Class	Sandy soil
Chemical Properties	5.5
pH (H_2O) (1:2.5)	5.3
pH($CaCl_2$) (1:5)	9.2
Organic carbon (g kg^{-1})	0.1
Total nitrogen (g kg^{-1})	8.0
Available phosphorus (mg kg^{-1})	1.7
Ca (cmol kg^{-1})	0.3
Mg(cmol kg^{-1})	0.4
Na (cmol kg^{-1})	0.2
K (cmol kg^{-1})	0.1
Exch. Ac. (cmol kg^{-1})	2.8
ECEC (cmol kg^{-1})	96
B. Sat (%)	18
Mn (mg kg^{-1})	27
Fe (mg kg^{-1})	3.0
Cu (mg kg^{-1})	4.0
Zn (mg kg^{-1})	

Exch. Ac = Exchangeable acidity, ECEC – Effective cation exchange capacity, B.Sat = Base saturation.

Table 2: Nutrient Composition of Poultry Manure and Cocoa Pod Husk

Nutrient composition	Poultry Manure	Cocoa Pod Husk
Organic C (%)	24.1	16.3
Total N (%)	3.5	1.5
C/N Ratio (%)	7.0	11.0
Total P (%)	2.9	1.2
K (%)	3.1	12.0
Ca (%)	2.6	3.4
Mg (%)	1.1	1.6
Zn (%)	0.5	0.2
Cu (%)	0.2	0.4
Fe (%)	2.8	1.3
Mn (%)	1.5	1.2

Organic C = Organic carbon, Total N = Total nitrogen,

Tables 3 and 4 show the effect of PM and CPH integration on soil chemical properties at Igba site at the end of 2019 and 2020 cropping seasons respectively. At the end of the first cropping season, integrated application of PM and CPH significantly ($P \leq 0.05$) influenced soil pH, exchangeable bases, exchangeable acidity, ECEC, total N, total organic carbon, available P and soil micronutrients. Integrated application of PM and CPH enhanced soil chemical properties better than the sole application of either of them in terms of soil pH, exchangeable bases, ECEC, total N, total organic carbon and available P. Plots with the integrated application had higher values of soil pH, exchangeable bases, ECEC, total N, total organic carbon, available P and lower values of exchangeable acidity and micronutrients than the plots with their sole application. The plots with the integrated application of 10 t ha^{-1} of each of the two inputs had the highest values of soil pH, exchangeable bases, ECEC, total N, total organic carbon, available P and also, had the lowest exchangeable acidity and micronutrients this was followed by the plots with the integrated use of 10 t ha^{-1} PM and 5 t ha^{-1} CPH or plots amended with the integrated use of 5 t ha^{-1} PM with 10 t ha^{-1} CPH.

At the end of the second cropping season, there were slight improvements in soil chemical properties such as soil pH, exchangeable bases, ECEC, total organic carbon and available P, while slight reductions in total N and the micronutrients were recorded in plots with the integrated application of the inputs and their sole application when compared with the first cropping season. Also, there were reductions in soil pH, exchangeable bases, ECEC, total N, total organic carbon and micronutrients in control plots. Plots amended with the integrated use of 10 t ha^{-1} PM and 10 t ha^{-1} CPH consistently had the highest soil pH, exchangeable bases, ECEC, total N, total organic carbon, available P and the lowest exchangeable acidity and micronutrients.

Table 3: Effect of Poultry Manure and Cocoa Pod husk Integration on the Soil Chemical Properties in 2019 Cropping Season

Trt ($t\ ha^{-1}$)	pH	Ca	Mg	K	Na cmol/kg	Ex.Ac	ECEC	Base Sat	Total N %	Total Org C	Av. P	Mn	Fe mg/kg	Cu	Zn
P_0CP_0	5.16c	2.51d	1.59c	0.40c	0.39a	0.12a	5.01c	97.52a	0.13b	1.39d	12.81d	24.91a	18.91a	3.48a	3.64a
P_0CP_5	5.73b	3.23c	1.70b	0.44c	0.41a	0.11a	5.90b	98.21a	0.12c	1.67c	17.82c	17.62b	14.92b	2.68b	2.74b
P_0CP_{10}	5.82b	3.37c	1.78ab	0.57b	0.43a	0.10b	6.25b	98.42a	0.14b	1.97b	20.13c	16.43c	15.41b	2.51c	2.58b
P_5CP_0	5.68b	3.2 9c	1.69b	0.41c	0.38b	0.09b	5.88b	98.41a	0.14b	1.75c	18.84c	18.71b	15.42b	2.72b	2.85b
P_5CP_5	6.05a	3.79b	1.78ab	0.65a	0.36b	0.09b	6.68a	98.72a	0.15a	1.96b	22.61b	16.32c	14.52c	2.69b	2.59b
P_5CP_{10}	5.97b	3.87ab	1.83a	0.63a	0.39a	0.08c	6.80a	98.81a	0.16a	1.98a	28.52a	16.03c	15.32b	2.61b	2.59b
$P_{10}CP_0$	6.11a	3.64b	1.83a	0.57b	0.38b	0.08c	6.39a	98.72a	0.14b	1.92b	24.41b	17.41b	13.81c	2.77b	2.50b
$P_{10}CP_5$	6.42a	4.05a	1.72b	0.66a	0.40a	0.08c	6.99a	98.81a	0.15a	2.09a	29.91a	16.42c	14.02c	2.68b	2.50b
P10CP10	6.47a	4.11a	1.88a	0.62a	0.40a	0.08c	7.08a	98.92a	0.16a	2.25a	31.11a	15.91c	13.02c	2.49c	2.56b
SE±	0.12	0.19	0.05	0.06	0.10	0.004	0.19	0.08	0.006	0.08	0.97	0.93	0.27	0.03	0.04

Means with the same letter in a column are not significantly different at $p \leq 0.05$.
P_0 = 0 t ha^{-1} PM, P_5 = 5 t ha^{-1} PM, P_{10} = 10 t ha^{-1} PM, CP_0 = 0 t ha^{-1} CPH, CP_5 = 5 t ha^{-1} CPH, CP_{10}= 10 t ha^{-1} CPH.
Trt = Treatment, Ex. AC. = Exchangeable acidity, ECEC = Effective cation exchange capacity, Base sat = Base saturation, Total organic C = Total organic carbon, Av. P = Available phosphorus.

Table 4: Effect of Poultry Manure and Cocoa Pod husk Integration on the Soil Chemical Properties in 2020 Cropping Season

Trt ($t\ ha^{-1}$)	pH	Ca	Mg	K	Na cmol/kg	Ex.Ac	ECEC	Base Sat	Total N %	Total Org C	Av. P	Mn	Fe mg/kg	Cu	Zn
P_0CP_0	4.71d	2.62d	1.50c	0.37e	0.35c	0.10a	4.95d	86.93b	0.12d	1.37d	11.44d	21.08a	16.26a	2.92a	3.15a
P_0CP_5	6.14b	3.47b	1.78b	0.53c	0.42a	0.09b	6.30b	98.51a	0.13c	1.75c	19.69c	16.38b	14.09c	2.67b	2.63b
P_0CP_{10}	6.21b	3.77b	1.88a	0.56c	0.44a	0.09b	6.75b	98.58a	0.13c	2.12a	26.08b	15.94c	13.82d	2.46c	2.47b
P_5CP_0	5.63c	3.06c	1.73b	0.46d	0.41a	0.09b	5.76c	98.16a	0.14b	1.75c	18.73d	20.54a	15.58b	2.96a	3.01a
P_5CP_5	6.06b	3.89a	1.84a	0.60b	0.39b	0.09b	6.82a	98.58a	0.14b	1.98b	22.57c	16.88b	14.18c	2.57c	2.48b
P_5CP_{10}	6.22b	3.89a	1.90a	0.67a	0.42a	0.09b	6.98a	98.57a	0.15a	2.03a	26.68b	15.77c	14.99b	2.51c	2.42b
$P_{10}CP_0$	6.23b	3.57b	1.79b	0.50d	0.39b	0.09b	6.33a	98.64a	0.14b	1.97b	23.17b	17.14b	14.29c	2.66b	2.49b
$P_{10}CP_5$	6.65a	4.16a	1.88a	0.73a	0.40b	0.08c	7.35a	98.88a	0.14b	2.16a	29.51a	15.17c	14.05c	2.56c	2.50c
$P_{10}CP_{10}$	6.43a	4.20a	1.93a	0.66b	0.41a	0.08c	7.27a	98.99a	0.15a	2.24a	32.87a	15.34c	13.12d	2.49c	2.51c
SE±	0.26	0.26	0.09	0.06	0.02	0.05	0.35	3.68	0.01	0.13	2.12	0.74	0.09	0.11	0.11

Means with the same letter in a column are not significantly different at $p \leq 0.05$.
P_0 = 0 t ha^{-1} PM, P_5 = 5 t ha^{-1} PM, P_{10} = 10 t ha^{-1} PM, CP_0 = 0 t ha^{-1} CPH, CP_5 = 5 t ha^{-1} CPH, CP_{10}= 10 t ha^{-1} CPH.
Trt = Treatment, Ex. AC. = Exchangeable acidity, ECEC = Effective cation exchange capacity, Base sat = Base saturation, Total organic C = Total organic carbon, Av. P = Available phosphorus.

The interaction effect of poultry manure (PM) and cocoa pod husk (CPH) integration on the growth characteristics of carrot is shown in Tables 5. Relative to control, integrated application of PM and CPH significantly ($P \leq 0.05$) influenced the growth characteristics of carrots. Growth characteristics of carrots were better enhanced in plots with the integrated application of CPH and PM than either of PM or CPH amended plots. At both cropping seasons, carrots in PM and CPH amended plots had better growth performance than the control plots. There were slight increases in growth characteristics of carrots at second cropping season in plots amended with PM or CPH or their combinations compared to control plots where reductions in growth characteristics measured were obtained. Plots with the integrated application of 10 t ha^{-1} of PM and 10 t ha^{-1} of CPH consistently had the best growth parameters in terms of plant height, leaf length and shoot dry matter. This was followed by plots with the integrated application of 10 t ha^{-1} PM and 5 t ha^{-1} CPH. The mean plant height values for the two cropping seasons for P_0CP_0, P_0CP_5, P_0CP_{10}, P_5CP_0, P_5CP_5, P_5CP_{10}, $P_{10}CP_0$, $P_{10}CP_5$, and $P_{10}CP_{10}$ were 38.9, 42.5, 52.4, 45.65, 46.30, 51.30, 45.85, 50.30 and 58.3 cm respectively. Plots without any treatment (P_0 CP_0) consistently had the poorest growth characteristics at both cropping seasons.

Table 5: Effect of Poultry Manure and Cocoa Pod Husk Integration on Growth Characteristics of Carrot

Treatment (t ha^{-1})	Plant height (cm)		Leaf length (cm)		Number of leaves		Shoot dry matter (%)	
	2019	2020	2019	2020	2019	2020	2019	2020
P_0CP_0	41.61c	36.21c	29.72d	25.81c	7.13a	6.77b	7.54d	7.13c
P_0CP_5	42.31c	42.72b	34.61c	33.93b	7.33a	7.40a	8.06c	7.69c
P_0CP_{10}	50.12b	54.73b	42.82b	38.72b	7.64a	7.72a	7.30d	7.52c
P_5CP_0	45.21c	46.11b	30.93c	31.82b	7.58a	7.65a	9.46b	9.55ab
P_5CP_5	45.12b	47.53b	31.23c	44.03a	7.69a	7.84a	8.89c	9.16b
P_5CP_{10}	52.31b	50.31a	31.22c	43.31a	7.55a	7.70a	9.07b	9.25b
$P_{10}CP_0$	45.42bc	46.32b	29.81d	32.52b	7.62a	7.77a	10.56a	9.97a
$P_{10}CP_5$	49.81b	50.82a	43.83b	45.03a	7.82a	7.89a	10.06a	10.3a
$P_{10}CP_{10}$	58.52a	58.11a	51.32a	50.81a	7.84a	7.92a	10.73a	10.9a
SE±	1.59	1.70	0.82	0.86	0.30	0.32	0.41	0.43

Means with the same letter (s) in a column are not significantly different at ($p \leq 0.05$). P_0 = 0 t ha^{-1} PM, P_5 = 5 t ha^{-1} PM, P_{10} = 10 t ha^{-1} PM, CP_0 = 0 t ha^{-1} CPH, CP_5 = 5 t ha^{-1} CPH, CP_{10} = 10 t ha^{-1} CPH.

The effect of the integrated application of PM and CPH on leaf nutrient concentration of carrot is shown in Table 6. Leaf nutrients concentration at both cropping seasons were significantly influenced ($P \leq 0.05$). The leaf nutrients concentration of N, P, K and Ca were better enhanced in plots treated with the integrated use of PM and CPH than the plots with the sole application of either of them. In the second cropping season, there were slight increases in the leaf nutrients concentration in plots amended with organic inputs either sole or combined. The mean leaf N concentration for the two cropping seasons for P_0CP_0, P_0CP_5, P_0CP_{10}, P_5CP_0, P_5CP_5, P_5CP_{10}, $P_{10}CP_0$, $P_{10}CP_5$, $P_{10}CP_{10}$ were 0.54, 0.63, 0.71, 0.61, 0.69, 0.62, 0.65, 0.71 and 0.68 %, respectively. The leaf P concentration for P_0CP_0, P_0CP_5, P_0CP_{10}, P_5CP_0, P_5CP_5, P_5CP_{10}, $P_{10}CP_{10}$, $P_{10}CP_5$ and $P_{10}CP_{10}$ for the two cropping seasons had the mean values of 0.46, 0.59, 0.66, 052, 0.61, 0.74, 0.58, 062 and 0.79%, respectively. The leaf K concentration for P_0CP_0, P_0CP_5, P_0CP_{10}, P_5CP_0, P_5CP_5, P_5CP_{10}, $P_{10}CP_0$, $P_{10}CP_5$ and $P_{10}CP_{10}$ for the two cropping seasons had the mean values of 5.03, 5.56, 6.01, 6.16, 6.30, 6.70, 6.20, 6.23 and 6.31 %, respectively.

Table 6: Effect of Poultry Manure and Cocoa Pod husk Integration on Leaf Nutrients Concentration of Carrot

Treatment (t ha^{-1})	N		P		K (%)		Ca		Mg	
	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
P_0CP_0	0.55c	0.53c	0.50d	0.43e	5.41c	4.66d	0.40d	0.34e	0.13b	0.11d
P_0CP_5	0.63b	0.62b	0.58c	0.61c	5.47c	5.64c	0.47c	0.49c	0.13b	0.12d
P_0CP_{10}	0.69a	0.72a	0.63b	0.69b	6.05a	5.97b	0.42d	0.46d	0.13b	0.13c
P_5CP_0	0.57c	0.64b	0.55c	0.48e	6.32a	5.99b	0.45c	0.44d	0.13b	0.12c
P_5CP_5	0.68a	0.70a	0.61b	0.61c	6.11a	6.49a	0.54b	0.62b	0.14a	0.15a
P_5CP_{10}	0.60b	0.61b	0.71a	0.76a	6.35a	7.05a	0.61a	0.68a	0.14a	0.14b
$P_{10}CP_0$	0.62b	0.67a	0.62b	0.55d	5.84b	6.67a	0.44c	0.46d	0.13b	0.13c
$P_{10}CP_5$	0.70a	0.72a	0.59b	0.65b	5.65b	6.16b	0.52b	0.52c	0.13b	0.15a
$P_{10}CP_{10}$	0.67a	0.68a	0.76a	0.82a	5.89b	6.16b	0.64a	0.70a	0.14a	0.15a
SE±	0.02	0.03	0.01	0.01	0.06	0.07	0.01	0.01	0.001	0.05

Means with the same letter in a column are not significantly different at $p \leq 0.05$.

P_0 = 0 t ha^{-1} PM, P_5 = 5 t ha^{-1} PM, P_{10} = 10 t ha^{-1} PM, CP_0 = 0 t ha^{-1} CPH, CP5 = 5 t ha^{-1} CPH, CP10 = 10 t ha^{-1} CPH.

The influence of the integrated use of poultry manure and cocoa pod husk on root yield characteristics of carrots is shown in Tables 7. The root yield characteristics of carrots were significantly ($P \leq 0.05$) influenced by the integrated use of PM and CPH at both cropping seasons. Integrated application of PM and CPH significantly ($P \leq 0.05$) influenced the root length, root dry matter, gross root yield, malformed roots and marketable root yield. The root yield characteristics were better enhanced in plots with integrated application of the organic inputs than the sole application of the organic inputs. Integrated application of 10 t ha $^{-1}$ PM with 10 t ha $^{-1}$ CPH produced carrots with the highest root yield characteristics in terms of root length, root diameter, root dry matter, gross root yield and marketable root yield. This was followed by carrots from plots amended with either 10 t ha^{-1} PM integrated with 5 t ha $^{-1}$ CPH or 5 t ha $^{-1}$ PM integrated with 10 t ha $^{-1}$ CPH at both cropping seasons. The mean gross root yield values for P_0CP_0, P_0CP_5, P_0CP_{10}, P_5CP_0, P_5CP_5, P_5CP_{10},$P_{10}CP_0$, $P_{10}CP_5$ and $P_{10}CP_0$ for the two cropping seasons were 16.01, 18.23, 18.32, 19.25, 19.9, 22.7, 23.37, 23.97 and 25.51 t ha $^{-1}$ respectively. The mean marketable root yield values for P_0CP_0, P_0CP_5, P_0CP_5, P_5CP_0, P_5CP_5, P_5CP_{10}, $P_{10}CP_0$, $P_{10}CP_5$ and $P_{10}CP_{10}$ were 15.75, 17.9, 17.8, 18.93, 18.27, 22.10, 22.62, 23.24 and 24.71 t ha $^{-1}$ respectively. Carrot root yield characteristics were better enhanced at the second cropping season than at the first cropping season. Also, there were reductions in root yield characteristics of carrots in control plots at the second cropping season.

Table 7: Effect of Poultry Manure and Cocoa Pod Husk Integration on Yield Characteristics of Carrot

Treatment (t ha^{-1})	Root length (cm)		Root diameter (cm)		Root dry matter (%)		Gross root yield (t ha^{-1})		Deformed roots (%)		Marketable yield (t ha^{-1})	
	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
P_0CP_0	8.71c	7.58c	1.39d	1.41c	8.42b	7.83b	17.40d	14.62c	2.00d	1.26d	17.05c	14.44c
P_0CP_5	9.67bc	9.86b	1.66c	1.69b	10.58a	10.79a	18.05d	18.41b	2.54c	1.60c	17.59c	18.12b
P_0CP_{10}	10.23b	10.43b	1.61c	1.67b	10.40a	10.52a	18.05d	18.59b	3.58b	2.26a	17.40c	18.17b
P_5CP_0	10.86b	11.28b	1.70b	1.73b	9.58b	9.77a	19.15c	19.34b	2.00d	1.27d	18.77c	19.09b
P_5CP_5	11.41a	11.72a	1.89a	1.94a	10.76a	11.08a	19.60c	20.19b	2.88c	1.81b	16.72d	19.82b
P_5CP_{10}	11.91a	12.14a	1.88a	1.95a	9.56b	9.94a	22.25b	23.14a	3.30a	2.07b	21.52b	22.66a
$P_{10}CP_0$	11.47a	11.70a	1.90a	1.92a	8.67b	9.84a	23.25b	23.48a	3.92a	2.46a	22.34b	22.90a
$P_{10}CP_5$	11.86a	12.10a	1.96a	2.02a	10.81a	11.03a	23.85b	24.09a	3.76a	2.37a	22.96b	23.52a
$P_{10}CP_{10}$	12.91a	13.04a	2.09a	2.12a	10.34a	10.96a	25.25a	25.51a	3.48a	2.19a	24.47a	24.95a
SE$\pm$	0.36	0.38	0.4	0.6	2.53	2.56	1.27	1.37	0.47	0.41	1.33	1.31

Means with the same letter in a column are not significantly different at $p \leq 0.05$.
P_0 = 0 t ha^{-1} PM, P_5 = 5 t ha^{-1} PM, P_{10} = 10 t ha^{-1} PM, CP_0 = 0 t ha^{-1} CPH, CP_5 = 5 t ha^{-1} CPH, CP_{10} = 10 t ha^{-1} CPH.

DISCUSSION

The coarse nature of the soil at the experimental site should have encouraged the leaching of the exchangeable bases and hence, the slightly acidic nature and the low nutrients status of the soil. Also, the intensive cultivation that had taken place at the site might have been responsible for the low nutrients' status of the soil. Therefore, a supplementary supply of plant nutrients from external sources such as organic manures will be needed for high performance of carrots. Poultry (PM) and cocoa pod husk (CPH) contained considerable content of N, P, K, Ca and micronutrients, which on mineralization of the manures would be released to the soil for use of crop. The relatively high concentration of organic carbon, total N, P exchangeable K, Ca and Mg of PM and CPH are expected to benefit the soil that was low in these properties. Organic manure has been shown to release nutrient elements to the soil and improve other soil chemical and physical properties, which could enhance crop growth and development (Ogbonna, 2008, Dauda *et al*., 2008, Uko *et al*., 2009). Poultry manure contains higher N, P and organic carbon compared to CPH, this result conforms with the report of Adediran *et al*. (2003) that poultry manure had the highest nutrients contents compared to other bulky organic manures such as market wastes, household wastes and farmyard manure. The low C:N ratio of PM (7) compared to that of CPH (11) obtained in the study implies that PM would readily decompose, mineralize and release nutrients to the soil faster than CPH.

Soil pH, organic carbon, total N, available P, exchangeable bases, ECEC were significantly enhanced by the application of PM, CPH and their integrations. Improvements in soil pH, organic carbon, total N, available P, exchangeable bases, ECEC and reductions in exchangeable acidity and the micronutrients could be related to the nutrients composition of PM and CPH. These improvements in nutrients status imply that they can be used for soil fertility management for sustainable production of carrots. In support of this view, Ojeniyi and Adejobi (2002), Ayeni (2010) and Akanbi *et al.* (2014) found that CPH increased soil pH, N, P, Ca, Mg and reduced micronutrients. They concluded that CPH could be used as a substitute for inorganic fertilizer in crop production. Improvements in nutrients status in the second cropping season in plots previously amended with PM, CPH and their integrations could be attributed to the slow release of nutrients from the organic manures, which must have prevented the nutrients from being leached down the soil profile. Hence, they have a significant residual effect on soil fertility status. In support of this views, Adeoeye *et al*. (2008) observed that organic manures provide nutrients slowly but maintain uniformity of supplying available nutrients throughout the growing season and at the same time, having residual effect on the soil nutrients status. Improvement in soil pH due to the organic amendments could be attributed to their high Ca and Mg contents. In support of this view, Ipinmoroti (2013) indicated that CPH contained high K, mg and Ca that are base elements that are capable of complexing Al^{3+}, Fe^{2+} and Mn^{2+} in acid soils. Hence, they increased soil pH and reduced the acidic nature of the studied soil.

Carrot growth parameters responded positively to PM, CPH and their integrated application, this positive response of carrot growth to PM and CPH application could be attributed to high nutrients supplied to the soil on partial or complete mineralization of the organic amendments. The result obtained conforms with the result obtained by Alice *et al.* (2014) that organic fertilizer application had a significant influence on the growth parameters of carrot. Reductions in growth parameters of carrots in the second cropping season in control plots and the increase obtained in the growth parameters of carrots in plots amended with PM, CPH and their integrations in the second cropping seasons could be attributed to the residual effects of the amendments. These views are in line with the views of Zingore *et al.* (2007), Adeniyan (2008), Amusan *et al*. (2011) and Chandha (2013) that organic manures have the capacity that can elicit crop growth responses over time and that the value of organic manures as biofertilizers extend considerably beyond the first year of application. Improved vegetative growth associated with integrated use of PM and CPH might be due to the improvement in the level of soil organic carbon, N and available P. This finding agrees with the result reported by Walker and Barnal (2004), Ahmad *et al.* (2014) and Appiah *et al.* (2017) that integrated use of organic manures enhance vegetative growth parameters of carrots.

Leaf nutrients content were significantly influenced by PM, CPH and their integrations. These improvements in leaf nutrients content might be due to the high concentration of these nutrients released to the soil on mineralization of PM and CPH for the utilization by the crop. Improvements in the leaf N, P, K, Mg and Ca in the second cropping season in plots amended with PM, CPH and their integrations might be attributed to their more lasting and residual effect. This view agrees with the finding of Eghball *et al.* (2004) that organic manure help in the gradual release of its nutrients into the soil, which makes it an ideal input for good carrot yield. Reductions in the leaf N, P, K, Ca and Mg in control plots in the second cropping season is an indication that the soil at the site of the field experiment require an external supply of these nutrients for optimum growth and yield performance of carrots.

The root yield parameters of carrot increased with the increased rates of PM, CPH and their integrations. The positive response of carrot in terms of root yield might probably be due to the low initial nutrients status of the experimental soil and the nutrients released to the soil by PM, CPH and their integrations. The results obtained are in conformity with the findings of Makinde *et al*. (2007), and Idem *et al.* (2012) in similar crops. They noted that crops response to fertilizer application is affected by the nutrient reserve in the soil and that crops respond more to fertilizer application in soils with very low nutrient content than soils of high nutrients reserve. The percentage of malformed roots increased with increasing rates of PM, CPH and their integrations. The increased malformed roots (rotten roots, forked roots, cracked roots) may be attributed to the improved soil moisture content of the amended plots. The improved moisture content might be responsible for the enhancement of biological activities in the soil, which might partly be responsible for the increased percentage of rotten roots. Also, improvement in the nutrients such as N, P, K and Mg in plots with the amendments might be responsible for the enhanced biological activities that led to rotten of roots. This view is in line with the finding of Khairul *et al.* (2015) that the percentage of malformed roots increased due to higher N levels in poultry manure amended plots.

CONCLUSION

The sole use of poultry manure, cocoa pod husk and their integrations significantly influenced soil nutrients status, growth, leaf nutrients content and root yield of carrot. The sole application of PM, CPH and their integrations were not effective in enhancing high carrot yield on immediate basis, but were found to have high residual effects on soil productivity and carrot root yield on the long-term basis. Hence, the use of these two amendments could help to improve the productive life of the soils and enhance high crops performance in the study area.

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