Sole and Integrated Application of Cocoa Pod Ash and Urea Fertilizer on Soil Chemical Properties and Performance of Kale (*Brassica oleracea*) in Derived Savanna Zone of Nigeria

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Abstract

Pot experiments were carried out at the Teaching and Research Farm of Landmark University, Omu-Aran, kwara State Nigeria between January and March (first crop) and April and June (second crop) 2015. The aim was to investigate the sole and integrated application of cocoa pod ash (CP) and urea fertilizer (UF) on soil chemical composition and performance of kale (*Brassica oleracea*). The treatments were 3 levels of UF (0, 100, 200 kg/ha) and 4 levels of CP (0, 5, 10 and 15 t/ha). These were combined to have 12 treatments. The 12 treatments were arranged in a Completely Randomised Design, replicated three times. For crops of kale (first and second crops), CP alone and integration with UF increased soil chemical properties compared with no application of either CP or UF. Treatments 5 t/ha cocoa pod ash + 100 kg/ha urea fertilizer (CP_5U_{100}) and 5 t/ha cocoa pod ash + 200 kg/ha urea fertilizer (CP_5U_{200}) consistently have the higher values of N, K, Ca and Mg in both times of cropping kale and the mean values of both crops. Treatments CP_5U_{100} and CP_5U_{200} have significantly higher and similar values of plant height, number of leaves and other yield parameters (root weight, stem weight, leaf weight, stem girth and stem length) of kale compared with other treatments. Compared with no application of CP or UF

(CP_0U_0), CP_5U_{100} and CP_5 U_{200} increased the leaf weight of kale by 84 and 85%, respectively. Therefore due to the rising cost of fertilizer, integration of cocoa pod ash at 5 t/ha with 100 kg/ha urea fertilizer is recommended for cropping of kale in derived savanna zone of Nigeria.

***Keywords*:** Cocoa Pod Ash, Urea Fertilizer, Kale, Soil Chemical Composition

Introduction

Vegetables are important in human's daily lives. Among the popular vegetable is kale. Kale (*Brassica oleracea*) is a leafy green vegetable that belongs to the Brassica family, a group of vegetable including cabbage, collards and Brussels sprouts. It is an annual crop, with sizes which varies with variety. Most are about 12-36 inches in width, 12-24 inches in height. The duration for its harvest is approximately 2 months depending on temperature (Damrosch, 2004). Although is a low temperature crop, which is now finding its way to hot tropical countries like Nigeria may be due to the benefits people derived from it compared with other leafy vegetables. Kale has been recognised as a good source of vegetable fibre which helps to reduce high cholesterol level thus helping in the prevention of atherosclerosis, it also help to keep the blood sugar levels under control and is an excellent vegetable for people with diabetes. The high protein content of kale confers on it the advantage as rich source of vegetable protein over other lesser known vegetables (Emuebu and Anyika, 2011). According to Emuebu and Anyika (2011) the proximate compositions of kale are carbohydrate 2.36%, fat 0.26%, crude protein 11.67%, moisture content 81.38%, crude fibre 3.00%, ash 1.33% and energy 58.46 Kcal/100g.

In order to be able to have optimum yield of kale in Nigeria where its production had been extended to, good and fertile soil is important. However, fertile arable land is declining in Nigeria; thereby necessitating the use of fertilizers to supplement soil nutrients especially N which is required for succulent leaves of kale. Over the past two decades, urea has replaced ammonium

sulphate and calcium ammonium nitrate as single N source used in crop production in Nigeria (Omolayo and Ayodele, 2007). The use of inorganic fertilizer like urea has proven to be more convenient than the use of organic fertilizers but chemical fertilizers have become very scarce in Nigeria and prices are high for average farmer, hence there is the need to search for organic amendments which could be utilized as fertilizer. The use of organic amendment is also limited by the large quantity needed to meet crop requirements. Judicious application of inorganic fertilizer along with organic manure is one of the concepts gaining importance as it forms the integrated soil fertility management (Iren et al., 2014).

Like every other crops, kale fresh weight, root fresh weight, stem dry weight and root weight had been reported (Pinpeagchan and Wanapu, 2015) to increase with application of encapsulated urea fertilizer in Thailand. Also, Gebeyehu and Kibret (2013) reported increase in kale yield using compost manure compared with chemical fertilizer in Ethiopia. Ash derived from cocoa pod husk has been found as useful source of both macro and micro nutrients for various crops in Nigeria (Ajayi et al., 2007; Akanbi et al., 2014). However, the effects of integrated nutrient supply as opposed to sole application of soil amendment and its effects on soil chemical properties and kale performance has not been investigated. It is expected that integrating the two amendments would have better effect on soil chemical properties and growth and yield of kale. Therefore this work investigated the sole and integrated application of cocoa pod ash and urea fertilizer on soil chemical composition and performance of kale in Omu- Aran, derived savanna zone of Nigeria.

Materials and Methods

The experiments were carried out at the Teaching and Research Farm, Landmark University, Omu-Aran, kwara state Nigeria between January and March 2015 and repeated again between April and June the same year to validate the results. Landmark University lies between Lat 8^{o} 9'N and long

5^{o} 61'E and is located in the derived savanna ecological zone of Nigeria. There are two rainy seasons, one from March to July and the other from mid –August to November. The mean annual rainfall in the area is about 1300 mm and mean annual temperature of 32^{o}C. The soil at Omu-Aran is an Alfisol classified as oxic Haplustalf or Luvisol. The area where soil samples were taken had been exposed to maize cultivation for two years.

Sample Preparation

Core soil samples were collected randomly from 0-15 cm depth at the Research and Teaching Farm of Landmark University, Omu-Aran, Kwara State, Nigeria using soil auger, mixed thoroughly and sieved with 2-mm sieve to remove stones and debris. 10 kg of the sieved soils were weighed into a polybag (30 x 17 cm) perforated at the bottom to allow for air and water movement. The polybags were randomly placed under a shed for unbiased application of treatments (amendments). The treatments were 3 levels of urea fertilizer (0, 100, 200 kg/ha) and 4 levels of cocoa pod ash (0, 5, 10 and 15 t/ha). These were combined to have 12 treatments, viz; (a) Cocoa pod ash 0 t/ha + Urea 0 kg/ha (CP_0U_0), (b) Cocoa pod ash 5 t/ha + Urea 0 kg/ha (CP_5U_0), (c) Cocoa pod ash 10 t/ha + Urea 0 t/ha ($CP_{10}U_0$), (d) Cocoa pod ash 15 t/ha + Urea 0 kg/ha ($CP_{15}U_0$), (e) Cocoa pod ash 0 t/ha + Urea 100 kg/ha (CP_0U_{100}), (f) Cocoa pod ash 5 t/ha + Urea 100 kg/ha (CP_5U_{100}), (g) Cocoa pod ash 10 t/ha + Urea 100 kg/ha ($CP_{10}U_{100}$), (h) Cocoa pod ash 15 t/ha + Urea 100 kg/ha ($CP_{15}U_{100}$), (i) Cocoa pod ash 0 t/ha + Urea 200 kg/ha (CP_0U_{200}), (j) Cocoa pod ash 5 t/ha + Urea 200 kg/ha (CP_5U_{200}), (k) Cocoa pod ash 10 t/ha + Urea 200 kg/ha ($CP_{10}U_{200}$) and (l) Cocoa pod ash 15 t/ha + Urea 200 kg/ha ($CP_{15}U_{200}$). The 12 treatments were arranged in a Completely Randomised Design with three replications.

Nursery and Transplanting of Kale

Kale seeds were pre-germinated in a covered and protected nursery in a germinating tray using a mixture of 50% top soil 50% grinded coconut fibre as a germinating media for 21 days. Seedlings were later transplanted into the polybags on the 4th of January for the first experiment and 6th of April for the second experiment to validate the results. One healthy seedling was transplanted into each polybag. Watering was done immediately after transplanting and thereafter every morning. Weeding was done manually by hand picking emerged weeds from each pot.

Application of Amendment

25 g, 50 g and 75 g cocoa pod ash were incorporated into the soil in the polybags representing 5, 10 and 15 t/ha equivalent. The treatments were incorporated into the soil using hand trowel and allowed to decompose for one week before transplanting kale into the polybags. Watering was done immediately and continued every morning. 0.5 g and 1 g of urea fertilizer equivalent to 100 and 200 kg/ha were applied into the polybags one week after transplanting kale.

Soil Sample Analysis

The surface soil (0-15 cm depth) samples taken from the site were bulked and sieved using 2-mm sieve for physical and chemical soil analysis, representing the initial soil analysis before incorporation of amendments. Soil samples were also taken at the end of the experiments on treatment basis and these were analysed for chemical properties as described by Pansu and Gautheyrou (2006). The particle-size analysis was done using hydrometer method (Gee and Or, 2002). Soil organic matter was determined by the procedure of Walkley and Black using the dichromate wet oxidation method (Nelson and Sommers, 1996). Total N was determined by the micro-Kjeldahl digestion method (Bremner, 1996). Available P was determined by Bray-1 extraction followed by molybdenum blue colorimetry (Frank et al., 1998). Exchangeable K, Ca

and Mg were extracted using 1M ammonium acetate. Thereafter K level was determined using a flame photometer, and Ca and Mg by the EDTA titration method (Hendershot et al., 2008). Soil pH was determined using a soil-water medium at a ratio of 1:2 with a digital electronic pH meter.

Preparation and Chemical Analysis of Cocoa Pod Ash

Dried cocoa pod husks were collected from a cocoa farm, burnt into ash and sieved with 2-mm sieve before application. Samples from the cocoa pod ash used for the study were taken for laboratory analysis to determine their nutrients composition. The samples were analysed for organic C, N, P, K, Ca and Mg as described by Okelabo et al. (2002).

Determination of Growth and Kale Yield Components

The height and number of leaves of each plant per polybag were measured at 4 and 6 weeks after transplanting. The plant height was measured from the soil level to the top of the highest growing point using a ruler. The number of leaves was determined by counting the number of fully expanded leaves. Two months after transplanting, the whole plant for each treatment was harvested and partitioned into 3; the leaves, the stem and the roots which were weighed separately. The fresh weight of the leaves, stem and roots were taken using a weighing balance known as Ohau model PA2102. The roots were cleaned from soil using clean water and allowed to dry for 24 hours under room temperature before taken the weight. The stem length was taken with a ruler while the stem girth was measured using the venier calliper.

Statistical Analysis

Data collected were subjected to statistical analysis of variance (ANOVA) using SPSS 17 and the Microsoft Excel 2007. The treatment means were compared using the Duncan's multiple range test (DMRT) at $p = 0.05$ probability level.

Results

Initial Soil Fertility Status and Chemical Properties of the Amendments Used for the Experiment

The physical and chemical properties of the soils (0-15 cm) potted in polybags before cropping and the chemical properties of the cocoa pod ash used for kale production are shown in Table 1 and 2, respectively. The results showed that the soils potted for the first and second crops of kale production have the same values of sand, silt and clay. The soils were sandy loam in texture. The soils were high in sand and low in both silt and clay. The soils were acidic and low in organic matter, total N, available P and exchangeable K, Ca and Mg according to the critical levels of 3.0% organic matter, 0.20% N, 10.0 mg/kg available P, 0.16-0.20 cmol/kg exchangeable K, 2.0 cmol/kg Ca and 0.40 cmol/kg exchangeable Mg recommended for crop production in ecological zones of Nigeria (Akinrinde and Obigbesan, 2000). It will therefore unable to sustain crop yield without the addition of external input. It was found that cocoa pod ash is high in K, Ca and Mg and low in N and P while urea is high in only N and absent with other nutrients. Therefore application of cocoa pod ash and urea fertilizer is expected to improve soil fertility and yield of kale.

Table 1. Soil physical and chemical properties (0-15 cm) of the soils used for the experiment

Parameters	First crop	Second crop
Sand (%)	76	76
Silt (%)	13	13
Clay (%)	11	11
Textural class	Sandy loam	Sandy loam
pH (water)	5.25	5.36
Organic matter (%)	2.24	2.21
Total N (%)	0.16	0.14
Available P (mg/kg)	9.5	9.3
Exchangeable K (cmol/kg)	0.14	0.14
Exchangeable Ca (cmol/kg)	1.8	1.9
Exchangeable Mg (cmol/kg)	0.36	0.32

Table 2. Nutrient composition of cocoa pod ash used as soil amendment

Nutrient	N (%)	P (%)	K (%)	Organic C (%)	C/N	Ca (%)	Mg (%)
Cocoa pod ash	1.27	1.22	14.01	16.97	13.36	3.33	2.1
Urea fertilizer	45	-	-	-	-	-	-

Effect of Sole and Integrated Application of Cocoa Pod Ash and Urea Fertilizer on Soil Chemical Properties

The results of the effect of sole and integrated application of cocoa pod ash and urea fertilizer on soil chemical properties are presented in Table 3. For both crops of kale (first and second crops), cocoa pod ash alone and integration with urea fertilizer increased soil chemical properties compared with no application of either cocoa pod ash (CP) or urea fertilizer i.e. CP_0U_0. Using the mean value, treatments $CP_{15}U_0$, $CP_{15}U_{100}$ and $CP_{15}U_{200}$ have the highest values of soil organic matter and P while CP_0U_0 have the least values. Treatments CP_5U_{100} and CP_5U_{200} consistently have the higher values of N, K, Ca and Mg in both times of cropping kale and the mean values of both crops. However, there were no significant differences in the application of cocoa pod ash (CP) at 5, 10 and 15 t/ha with all its combinations with urea fertilizer. Also there were no significant differences in the soil organic matter, N, P, K, Ca and Mg values between urea fertilizer applied at 100 and 200 kg/ha.

Table 3. Effect of sole and integrated application of cocoa pod ash and urea fertilizer on soil chemical properties (0-15 cm depth) at the end of first and second crops of kale

	SOM (%)			N (%)			P (mg/kg)			K (cmol/kg)			Ca (cmol/kg)			Mg (cmol/kg)		
	1st crop	2nd crop	Mean	1st crop	2nd crop	Mean	1st crop	2nd crop	Mean	1st crop	2nd crop	Mean	1st crop	2nd crop	Mean	1st crop	2nd crop	Mean
CP_0U_0	2.10c	1.96c	2.03	0.15f	0.14g	0.15	9.1b	8.3d	8.7	0.13e	0.12d	0.13	1.9b	1.6d	1.8	0.33d	0.31d	0.32
CP_5U_0	3.91ab	3.56b	3.74	0.31c	0.26d	0.29	13.6ab	10.1bc	11.9	0.18bc	0.20ab	0.19	2.8a	2.4a	2.6	0.44a	0.40a	0.42
$CP_{10}U_0$	4.40a	3.72ab	3.91	0.32c	0.27cd	0.30	13.8ab	10.8ab	12.3	0.17cd	0.20ab	0.19	2.8a	2.4a	2.6	0.43ab	0.40a	0.42
$CP_{15}U_0$	4.12a	3.89ab	4.01	0.32c	0.27cd	0.30	13.9a	11.1a	12.5	0.17cd	0.19b	0.18	2.9a	2.4ab	2.7	0.43ab	0.40a	0.42
CP_0U_{100}	2.11c	1.96c	2.04	0.18e	0.16f	0.17	9.2b	9.4c	9.3	0.16d	0.12d	0.14	1.9c	1.7cd	1.8	0.35cd	0.31d	0.33
CP_5U_{100}	3.93ab	3.58ab	3.76	0.43ab	0.33ab	0.38	13.9a	10.4ab	12.2	0.20a	0.21a	0.21	2.8a	2.5a	2.7	0.46a	0.41a	0.44
$CP_{10}U_{100}$	4.10a	3.71ab	3.92	0.36bc	0.29c	0.33	14.1a	10.8ab	12.5	0.18bc	0.21a	0.20	2.9a	2.5a	2.7	0.46a	0.41a	0.44
$CP_{15}U_{100}$	4.14a	3.86a	4.00	0.35bc	0.30c	0.33	14.2a	11.3a	12.8	0.19ab	0.20ab	0.20	2.9a	2.4a	2.7	0.45a	0.40a	0.43
CP_0U_{200}	2.13c	1.97c	2.05	0.21d	0.19e	0.20	9.4b	8.5d	8.9	0.17cd	0.13cd	0.15	1.9b	1.7cd	1.8	0.35cd	0.31d	0.33
CP_5U_{200}	3.95ab	3.58ab	3.77	0.44a	0.34a	0.39	13.8ab	10.7ab	12.3	0.20a	0.21a	0.21	2.9a	2.5a	2.7	0.45a	0.42a	0.44
$CP_{10}U_{200}$	4.15a	3.73ab	3.94	0.40b	0.34a	0.37	14.2a	10.9ab	12.6	0.18bc	0.20ab	0.19	2.9a	2.5a	2.7	0.45a	0.41a	0.43
$CP15U_{200}$	4.14a	3.90a	4.02	0.39b	0.33ab	0.36	14.2a	11.3a	12.8	0.18bc	0.19b	0.19	2.9a	2.4a	2.7	0.44a	0.41a	0.43

Mean values in a column under any given treatment followed by the same letter (s) do not differ significantly at p = 0.05 level of probability using the Duncan's multiple range test (DMRT)

Effect of Sole and Integrated Application of Cocoa Pod Ash and Urea Fertilizer on Plant Height and Number of Leaves of Kale

The results of the effect of sole and integrated application of cocoa pod ash (CP) and Urea fertilizer (UF) on plant height and number of leaves of kale are shown in Figure 1 and 2, respectively. Results revealed that when the effect of cocoa pod ash (CP) was considered at fixed rate of urea fertilizer, application of cocoa pod ash (CP) increased plant height and number of leaves of kale relative to the control, there were however no significant differences between 5, 10 and 15 t/ha cocoa pod ash (CP). Similarly when urea was considered at fixed rate of cocoa pod ash (CP), plant height of kale increased relative to no application of urea and cocoa pod ash (CP), however 100 and 200 kg/ha urea produced similar values. When cocoa pod ash and urea was integrated together, CP_5U_{200} and CP_5U_{100} have significantly higher but similar values of plant height and number of leaves compared with other treatments. CP_0U_0 have least values. In all cases, CP_5U_0, $CP_{10}U_0$ and $CP_{15}U_0$ have similar values of plant height and number of leaves of kale. CP_5U_{100}, $CP_{10}U_{100}$ and $CP_{15}U_{100}$ also have similar values. Similarly, CP_5U_{200}, $CP_{10}U_{200}$ and $CP_{15}U_{200}$ also have statistically similar values of plant height and number of leaves of kale.

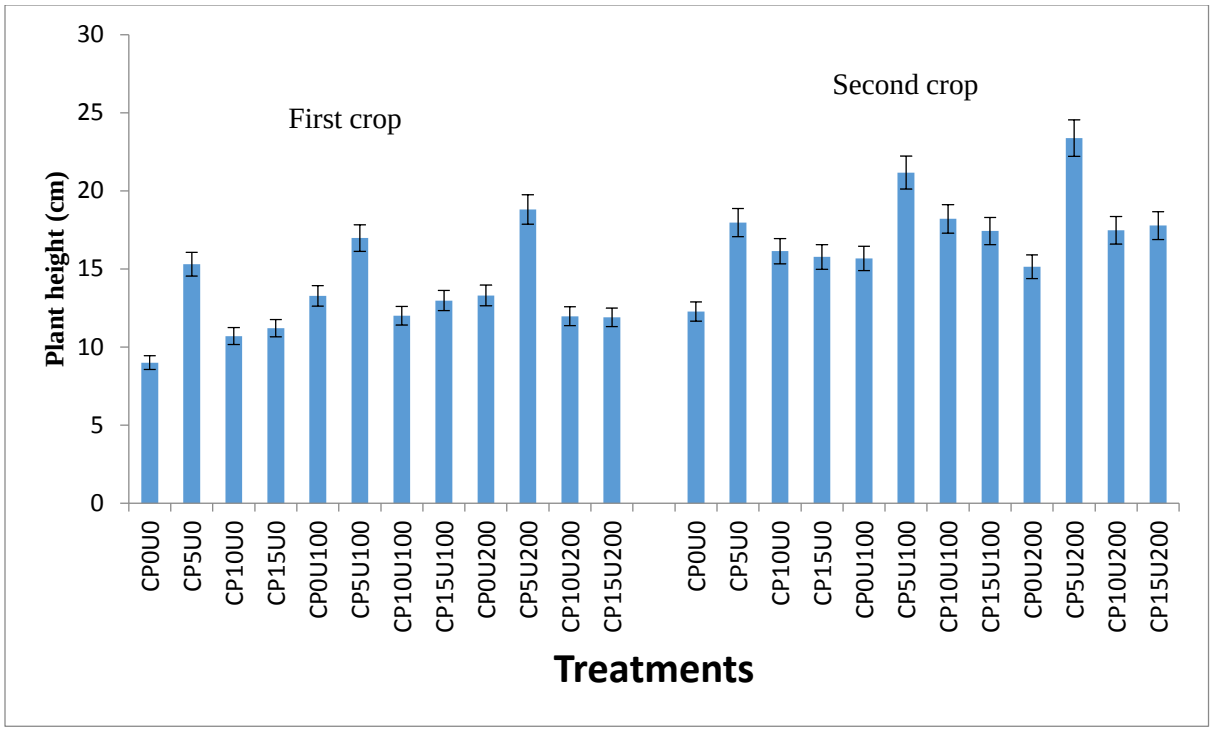

Figure 1. Effect of cocoa pod ash (CP) and urea fertilizer (UF) on plant height of kale in the first and second crops. Vertical bars show standard errors of paired comparisons.

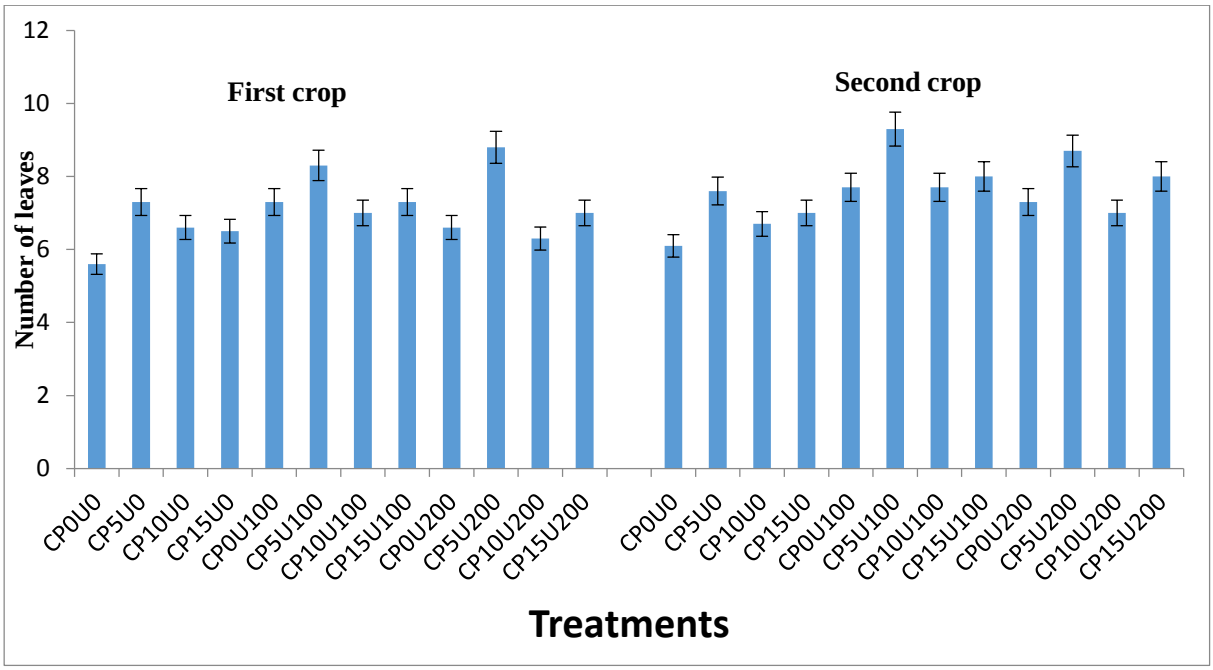

Figure 2. Effect of cocoa pod ash (CP) and urea fertilizer (UF) on number of leaves of kale in the first and second crops. Vertical bars show standard errors of paired comparisons.

Effect of Sole and Integrated Application of Cocoa Pod Ash and Urea Fertilizer on Yield Parameters of Kale

Table 4 shows the result of sole and integrated application of cocoa pod ash and urea fertilizer on mean yield parameters of first and second crops of kale. Cocoa pod ash or urea alone and integration of both increased the yield parameters of kale (root weight, stem weight, leaf weight, stem girth and stem length) significantly compared with no application of cocoa pod ash or urea fertilizer i.e. CP_0U_0. Treatments CP_5U_{200} and CP_5U_{100} have the higher values of yield parameters, although their values were statistically not significant. Also CP_5U_0, $CP_{10}U_0$ and $CP_{15}U_0$ have statistically similar values. Likewise treatments CP_5U_{100}, $CP_{10}U_{100}$ and CP_{15} U_{100} and treatments CP_5U_{200}, $CP_{10}U_{200}$ and $CP_{15}U_{200}$ have similar values for all yield parameters. Compared with no application of cocoa pod ash or urea fertilizer (CP_0U_0), CP_5U_{100} and CP_5U_{200} increased the leaf weight of kale by 84 and 85%, respectively.

Table 4. Effect of sole and integrated application of cocoa pod ash and urea fertilizer on mean yield parameters of first and second crops of kale

	Root weight (g)	Stem weight (g)	Leaf weight (g)	Stem girth (cm)	Stem length (cm)
CP_0U_0	0.22f	0.69e	6.10f	0.26g	4.2d
CP_5U_0	0.98cd	1.76cd	26.56cd	0.44cd	5.43bc
$CP_{10}U_0$	0.50ef	1.27cd	17.90de	0.37bf	5.40bc
$CP_{15}U_0$	0.47e	1.20cd	15.65e	0.29f	5.17bc
CP_0U_{100}	0.73cd	1.07de	19.65cd	0.33def	5.97ab
CP_5U_{100}	1.58ab	2.48ab	38.08ab	0.48ab	6.33a
$CP_{10}U_{100}$	1.21ab	1.98bc	28.78bc	0.46abc	5.70b
$CP_{15}U_{100}$	1.08abc	1.41cde	28.45bc	0.36cf	5.00b
CP_0U_{200}	0.55ef	1.03de	17.38de	0.313f	5.40b
CP_5U_{200}	1.61a	2.96a	40.82a	0.52a	6.77a
$CP_{10}U_{200}$	1.22b	1.69cd	28.45bc	0.42c	5.33bc
$CP15U_{200}$	1.20b	1.89bc	31.93ab	0.42c	5.67b

Mean values in a column under any given treatment followed by the same letter (s) do not differ significantly at p = 0.05 level of probability using the Duncan's multiple range test (DMRT)

The correlation coefficient (r) values between soil organic matter (SOM), N, P, K, Ca and Mg and growth and yield parameters of kale plant (plant height, number of leaves, root weight, stem weight, leaf weight, stem girth and stem length) are shown in Table 5. The Table shows that SOM was only significant for stem weight, leaf weight and stem girth. N and K were not significant only for stem length. P, Ca and Mg were also not significant only for plant height, number of leaves and stem length.

Table 5. Correlation between soil chemical properties and growth and yield parameters of kale

	Plant height	Number of leaves	Root weight	Stem weight	Leaf weight	Stem girth	Stem length
SOM	0.395ns	0.347ns	0.553ns	0.811*	0.598*	0.594*	0.222ns
N	0.680*	0.643*	0.819**	0.825**	0.850**	0.799**	0.518*
P	0.427ns	0.400ns	0.604*	0.607*	0.647*	0.619*	0.275ns
K	0.704*	0.655*	0.787**	0.816**	0.830**	0.818**	0.509*
Ca	0.494ns	0.445ns	0.637*	0.665*	0.676*	0.666*	0.312ns
Mg	0.565ns	0.519ns	0.706*	0.734*	0.742*	0.741*	0.391ns

Discussion

The increase in soil organic matter (SOM), N, P, K, Ca and Mg concentrations due to the application of cocoa pod ash and urea fertilizer was consistent with the analysis recorded for the two soil amendments in this study and the use of cocoa pod ash and urea fertilizer for improving soil fertility in crop production (Ayeni, 2008; Odedina et al., 2003). Sobamiwa and Longe (1994) also showed that cocoa pod ash contains N, P, K, Ca, Mg and micronutrients. The non significant differences in the application of cocoa pod ash (CP) at 5, 10 and 15 t/ha in combination with 100 and 200 kg/ha urea fertilizer suggested that 5 t/ha cocoa pod ash (CP) is sufficient for kale. Also, the non-significant between 100 and 200 kg/ha urea fertilizer suggested that 100 kg/ha urea is sufficient for kale production.

Cocoa pod ash or urea fertilizer alone and the integration of both increased growth and yield parameters of kale compared with no application of either cocoa pod ash or urea fertilizer i.e. CP_0U_0, This showed that soil in the area lacked essential nutrients especially those that enhance growth and development of kale. This is supported by the result of the initial fertility of the soil before experimentation. The result indicated low organic matter content and other nutrients. Treatments CP_5U_{100} and CP_5U_{200} have the highest values of kale growth and yield parameters. This result is also consistent with the soil chemical properties of these treatments. In all cases of the growth and yield parameters, the values of CP_5U_{100} and CP_5U_{200} are similar. This implies that CP_5U_{100}, that is application of cocoa pod ash at 5 t/ha and urea fertilizer at 100 kg/ha is adequate for growth and yield of kale. Any addition of cocoa pod ash or urea fertilizer above these rates of cocoa pod ash and urea fertilizer will be at luxury and will contribute less to growth and yield of kale. Tisdale et al. (1993) had noted that plant response to fertilizer is higher in soil with low nutrient content than soil with high nutrient reserve. Consequently when the soil nutrient level has been raised to high level for kale, further increase in rate will bring about low or no response. High levels of some nutrients elements have been reported to inhibit the availability of others especially micronutrient elements (Harper, 1983). The positive and significant correlation of all growth and yield parameter of kale considered in this study with N and K suggests that N and K are important in kale production

Conclusion

For both crops of kale (first and second crops), cocoa pod ash alone and integration with urea fertilizer increased soil chemical properties compared with no application of either cocoa pod ash or urea fertilizer. Treatments 5 t/ha cocoa pod ash + 100 kg/ha urea fertilizer (CP_5U_{100}) and 5 t/ha cocoa pod ash + 200 kg/ha urea fertilizer (CP_5U_{200}) consistently have the higher values of N, K,

Ca and Mg in both times of cropping kale. Similarly, treatments CP_5U_{100} and CP_5U_{200} have significantly higher and similar values of plant height, number of leaves and other yield parameters (root weight, stem weight, leaf weight, stem girth and stem length) of kale compared with other treatments. The positive and significant correlation of all growth and yield parameter of kale considered in this study with N and K suggests that N and K are important in kale production. Therefore due to the rising cost of fertilizer, integration of cocoa pod ash at 5 t/ha with 100 kg/ha urea fertilizer is recommended for cropping of kale in the guinea savanna zone of Nigeria.

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