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Comparative evaluation of different organic fertilizers on the soil fertility, leaf mineral composition and growth of bitter kola seedlings

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Abstract: The effect of oil palm bunch ash, spent grain, poultry and turkey manures applied solely and their supplemented forms, as sources of fertilizer on soil fertility, leaf mineral composition and growth of bitter kola (*Garnicia colae*) seedlings was investigated at Akure in the rainforest zone of Nigeria. The eight organic fertilizer treatments: spent grain, oil palm bunch ash, poultry manure, turkey manure, spent grain + poultry manure, spent grain + turkey manure, oil palm bunch ash + poultry manure and oil palm bunch ash + turkey manure were applied at 40g per 10kg soil filled polybag (8t/ha dry weight) with a reference treatment 400kg/ha NPK 15-15-15 fertilizer (2g per bag) and arranged in a completely randomized design (CRD) and replicated three times. The supplemented or amended treatments were applied at a 50:50% by weight (20g each). The results showed that these organic fertilizers increased the growth parameters, soil and leaf N, P, K, Ca and Mg, soil pH and organic matter significantly ($P<0.05$) compared to the control treatment. The supplements of oil palm bunch ash and wood ash with poultry and turkey manures increased consistently the growth, soil and leaf mineral compared to their sole forms. Oil pal bunch ash + poultry manure increased the leaf N (52%), P (27%), K (44%), Ca (39%) and Mg (51%) compared to the sole application of poultry manure. When compared with NPK 15-15-15 fertilizer, the oil palm bunch ash + poultry manure treatment increased the plant height (40%) leaf area (50%), stem girth (45%) number of leaves (53%), and fresh shoot weight (29%). For soil chemical composition, the oil palm bunch ash + poultry manure treatment increased the soil pH (28%), O.M. (92%), P (26.3%), Ca (99%), Mg (98%) and Na (93%) compared to the NPK 15-15-15 fertilizer. However, the NPK 15-15-15 fertilizer increased the soil K by 11% compared to the former. The high soil K/Ca, K/Mg and P/Mg ratios in the NPK 15-15-15 fertilizer treatment led to an imbalance in the supply of P, K, Ca and Mg nutrient to bitter kola seedlings. In these experiments, oil palm bunch ash + poultry manure applied at 8t/ha was most effective treatment in improving bitter kola growth parameters, soil and leaf mineral composition.

Key words: organic fertilizer, soil fertility, leaf mineral composition, growth parameters, bitter kola seedlings.

تقييم مستويات مختلفة من الأسمدة العضوية على خصوبة التربة، ومحتوى الأوراق من المعادن ونمو الشتلات كولا المرة

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الملخص: تهدف الدراسة إلى دراسة تأثير إضافة زيت رماد عذوق النخيل ومهروس الحبوب وسماد الدواجن الديك الرومي العضوي كمصدر من مصادر الأسمدة على خصوبة التربة بشكل منفرد أو خليط، محتوى الأوراق من العناصر الغذائية و نمو شتلات نبات الكولا المرة (*Garnicia caiae*). أجريت التجربة في الغابات المطيرة في اكيور في نيجيريا. وزعت معاملات الأسمدة العضوية ضمن تصميم القطاعات العشوائية الكاملة بثلاث مكررات على ثماني مستويات الحبوب المهروسة، وزيت رماد النخيل، روث الدواجن، روث الديك الرومي، مهروس الجيوب+ روث الدواجن، مهروس الحبوب+روث الديك الرومي، زيت رماد عذوق النخيل+ روث الدواجن و زيت رماد عذوق النخيل+ روث الديك الرومي

تم إضافة هذه المعاملات بمعدل 40 غم لكل 10 كغم التربة (80 طن/للهكتار وزن جاف) مقارنة مع 400 كغم/هكتار سماد مركب (15-15-15). المعاملات التكميلية أضيفت بنسبة وزنيه 50:50% (20 غم لكل معاملة). أظهرت معاملات السماد العضوي زيادة إحصائية معنوية ($p<0.05$) في عوامل النمو، محتوى التربة والأوراق من النيتروجين الفسفور البوتاسيوم الكالسيوم والمغنيسيوم وكذلك على درجة حموضة التربة و مستوى المادة العضوية مقارنة مع الشاهد. معاملات خلط زيت رماد النخيل ورماد الخشب مع روث الدواجن والديك الرومي زادت من النمو ومحتوى التربة والأوراق من العناصر الغذائية مقارنة مع المعاملات المفردة (بدون خلط). أظهرت معاملة زيت رماد عذوق النخيل+ روث الدواجن زيادة في محتوى الأوراق من النيتروجين (9.4%)، والفسفور (27%)، البوتاسيوم (28%) والكالسيوم (39%) والمغنيسوم (51%) مقارنة مع معاملة روث الدواجن منفردا. كذلك أظهرت معاملة زيت رماد عذوق النخيل+ روث الدواجن زيادة في معدل طول النبات (40%)، محيط الساق (59%) عدد الأوراق (45%) مساحة الورقة (53%) ووزن المجموع الخضري (29%) مقارنة مع معاملة الشاهد. كذلك أظهرت المعاملة زيادة في درجة حموضة التربة (28%)، مستوى المادة العضوية (92%) الفسفور (26.3%) الكالسيوم (99%) المغنيسيوم (98%) والصوديوم (29%) مقارنة من معاملة الشاهد. بينما كان محتوى التربة من البوتاسيوم في معاملة الشاهد أعلى بمعدل 11% مقارنة مع معاملة زيت رماد عذوق النخيل+ روث الدواجن. إن ارتفاع نسبة بوتاسيوم التربة إلى الكالسيوم وكذلك ارتفاع نسبة بوتاسيوم التربة إلى المغنيسيوم في معاملة الشاهد أدى إلى التأثر على مدى إتاحة عنصر الفسفور والبوتاسيوم والكالسيوم والمغنيسيوم للنبات. أظهرت هذه التجربة أن معاملة إضافة زيت رماد عذوق النخيل+ روث الدواجن بمعدل 8 طن/هكتار كانت الأفضل في تحسين نمو نبات الكولا ومحتو الأوراق والتربة من العناصر الغذائية.

الكلمات المفتاحية: السماد العضوي، خصوبة التربة، محتوى الأوراق من العناصر، شتلة الكوالا.

Introduction

Bitter kola (*Garnicia colae*) belongs to the family sterculiaceae and it is an important tree species occurring in the humid rainforest zones of West Africa (elevation 10m, lat 4^{o} N and 20^{1} N, 5^{o1} W 18^{1} E while the annual precipitation is 1444mm). In Nigeria, the species found mainly in homestead farmlands of Southern Nigeria and is identified as bitter kola due to the bitterness of its fused cotyledon (seeds).

Bitter kola is highly valued because of its wide range of uses, which include the fruits, the seeds, the stems and the roots. Olapade (2000) reported that bitter kola is very high in Fe, beta carotene and anti-oxidant, which help to prevent high blood pressure and anemia in the human body. The bitter component of the crop is the medicinal property which also helps the breakdown of glycogen (liver sugar level) to reduce sugar accumulation in the body.

In spite of the medicinal and economic importance of the crop, it is rapidly moving towards extinction because of the difficulty in raising it from seeds in the nursery (i.e. long germination period) and the situation is worsened by continued decline in soil fertility levels. Efforts to supplement the soil nutrient status with inorganic fertilizers are limited by the high cost of purchasing fertilizers especially for the poor resource farmers and acute scarcity at time of planting (Aduayi, 1980, Agbede and Kalu 1990, Obi and Ofoduru, 1997).

The tendency to supply all plant nutrients through synthetic fertilizers should be reconsidered in the future because this has a deleterious effect on soil productivity on a long term basis (Yadav and Prassad, 1992). Therefore, there is a strong incentive to look for alternative, locally produced organic fertilizers that are cheap, sustainable and environmentally compatible to raise bitter kola seedlings in large quantities for the establishment of commercial plantations.

This is an income source for the farmers either in the cities or rural areas.

Except Obatolu (1995), Moyin-Jesu and Atoyosoye (2002), Moyin-Jesu (2003), Moyin-Jesu and Ojeniyi, 2006, and Moyin-Jesu (2007) who reported the use of spent grain, poultry manure, rice brain and saw dust as fertilizers for coffee, locust bean, maize, amaranthus and okra. There is a scarcity of research information on use of poultry manure, turkey manure, spent grain (i.e. sorghum based grain) and oil palm bunch ash to raise bitter kola seedlings in the nursery and field establishment.

The objectives of this study were (i) to determine growth performance of bitter kola seedlings as influenced by the application of different organic fertilizers in the nursery and (ii) to determine the effect of these organic fertilizers on the leaf mineral composition of bitter kola and soil conditions.

Materials and Methods

The experiments were carried out at Akure in the rainforest zone of Nigeria (elevation 10m 7^{o} 15^{1} N, 5^{o} 15^{1} E). The rainfall is between 1100 and 1500mm per annum and average temperature is 24^{o} C. The soil is sandy oxic paleustalf (Alfisol). Soil survey staff (1999).

The experiment took place between 1999 and 2001 on the same site. The first experiment lasted for ten months starting between November 1999 and August 2000, the second experiment took place between November 2000 and August 2001.

Soil sampling and analysis before planting

Core soil samples were collected randomly from the 0-15cm depth on the site using a soil auger. Soil was then mixed thoroughly and the bulk sample was taken to the laboratory, air-dried and sieved to pass through a 2mm screen for chemical analysis.

The soil pH (1:1 soil/water) and (1:2 soil/0.01M $CaCl_2$ solution) was determined using a glass calomel electrode system (Crockford and Nowell, 1956) while organic matter was determined by the wet oxidation chromic acid digestion method (Walkley and Black, 1934).

The soil N was determined by the microkjedahl method (AOAC, 1970) while available soil P was extracted by the Bray P1 extractant, measured by the Murphy blue colouration and determined on a spectronic 20 at 882 Um (Murphy and Riley, 1962). Soil K, Ca, Mg and Na were extracted with a 1M NH_4OAC, pH 7 solution, then analysed with a flame. Photometer while Mg was determined with an atomic absorption spectrophotometer (Jackson, 1958).

The exchangeable acidity (H^4 and Al^{3+}) was measured from 0.1M HCl extracts by titrating with 0.1M NaOH (McLean, 1965). Micronutrients (Cu, Zn and Fe) were extracted with 0.1M HCl (Ogunwale and Udo, 1978) and read on a Perkin Elmer atomic absorption spectrophotometer.

Determination of soil physical properties

The physical properties of the soil on the site were determined before pre-nursery and nursery experiments. The soil bulk density (Mgm^{-3}) was determined by core method (Ojeniyi, 1985) while the percent porosity was calculated from the bulk density values. The particle size analysis of the soil was done by the hydrometer method (Bouycous, 1951).

Source and preparation of organic materials

Spent grain and oil palm bunch ash were obtained from the International Breweries Limited and the oil palm processing unit of Federal College of Agriculture Akure while the poultry and turkey manures were obtained from their

pens in the livestock unit of Federal College of Agriculture, Akure.

The organic materials were processed to allow decomposition. The oil palm bunch ash was sieved to remove pebbles, stones and other wastes while the spent grain was partially composted for six weeks. The turkey and poultry manures were air-dried and stacked to allow a quick mineralization process.

Chemical analysis of the organic materials used

Two grams each of the processed forms of the organic materials used were analysed. The N content was determined by the kjedahl method (Jackson, 1964), while the determination of other nutrients such as P, K, Ca, Mg, Fe, Zn, Cu and Mn was done using the wet digestion method based on 25-5-5ml of HNO_3 – H_2SO_4 – $HClO_4$ acids (AOAC, 1970). The organic carbon (%) was determined by a wet oxidation method using a chromic acid digestion (Walkley and Black, 1934). The data on the leaf mineral composition of bitter kola seedlings are presented in Table 2.

Collection of bitter kola seeds

Ripe fruits of bitter kola trees were harvested from the few trees in Federal College of Agriculture, Akure. Seed extraction was achieved by splitting the fruits with a sharp knife, the seeds were washed to remove fluidy mesocarp mesh on them, air dried for 72 hours at room temperature, bagged in a poly sac, labeled and stored properly to prevent insect attack.

Pre-nursery establishment of bitter kola seedlings

Five seed boxes of (90 x 60 x 30cm) size each were filled with topsoil and the mature seeds of bitter kola were planted on November 10, 1999. A shed was erected for the pre-nursery to prevent the seeds from desication and cultural practices such as weeding, watering and the spraying of karate 0.5L per 10L of water (25g a.i lambda cyhalothrum) against termite infestation were carried out.

The planted bitter kola seeds germinated after four months on February 20, 2000, they were transplanted to the nursery. The second pre-nursery experiment was reported on the same site between November 5, 2000 and February 12, 2001 and the same procedure was followed as described above.

Nursery establishment of bitter kola seedlings

The site was cleared and a shed was erected for the nursery. The bulk soil taken from the site (0-15cm depth was sieved to remove stones and plant debris and 10kg of the sieved soil was placed into a polybag (30x17cm).

There were eight organic fertilizer treatments: poultry manure, turkey manure, spent grain, oil palm bunch ash, spent grain + turkey manure, spent grain + poultry manure, oil palm bunch ash + turkey manure and oil palm bunch ash + poultry manure. 40g of each organic treatment was applied to 10kg soil (8t/ha), with three replications and arranged in a completely randomized design (CRD). A treatment with 400kg/ha NPK 15-15-15/2g per 10kg soil) served as a reference along with a control treatment (no fertilizer, no manure). The amended treatments were applied at a 50:50% ratio by weight (20g each).

The treatments were incorporated into the soil using a hand trowel and allowed to decompose for one week before transplanting the germinated bitter kola seedlings from the pre-nursery to the poly bags at the nursery site in the evening on March 16, 2000. Watering was done immediately and continued every morning and evening until the rain was steady in the first week of April for full establishment.

Agronomic practices such as weeding started at two week intervals until 16 weeks after transplanting. Spraying of Karate (lambda cyhalotrin 720 EC) at 0.5L per 10L of water for termites control, started at 3, 6, 9 and 12 weeks after transplanting.

The measurement of growth parameters such as plant height, leaf population, leaf area and stem girth started at the third week after transplanting and continued weekly until 20 weeks after transplanting (WAT).

Representative leaf samples from top, middle and lower parts of the seedlings, were randomly taken at 21 weeks after transplanting per each treatment using a knife, packed into labeled envelopes and oven dried for 24 hours at 70^{o}C. The dried leaf samples were dry ashed using a muffle furnace at 450^{o}C for six hours. The ash was made into a 50ml solution, filtered and analysed for N, P, K, Ca and Mg contents as described by AOAC (1970).

At 26 weeks after transplanting in the nursery, the seedlings were ready for final transplanting in the field and the fresh shoot weights were determined. Soil samples were taken in each treatment, air-dried, sieved and analysed for N, P, K, Ca, Mg, soil pH and O.M as described earlier.

The second experiment for the establishment in the nursery of bitter kola seedlings took place between March 10, 2001 and August 6, 2001. The agronomic practices such as weeding, spraying, measurement of growth parameters and leaf and soil analysis after planting were as described above in the first experiment. The seedlings after five months in the nursery were transplanted to the field for establishment.

Statistical analysis

The average data obtained for the growth parameters, leaves and soil chemical composition of bitter kola seedlings for the two experiments (between 1999 to 2001) were analysed using ANOVA with an F-test. The treatment means were compared using a Duncan Multiple Range Test at the 5% probability level (Gomez and Gomez, 1984).

Results

The physical and chemical properties of the soil are presented in Table 1. Based on the established critical levels for soils in Southwest Nigeria, the soil was acidic with pH 5.3 and low in organic matter compared to the critical level of 3% O.M. (Agboola and Corey, 1973).

The total N is less than 0.15% which is considered optimal for most crops (Sobulo and Osiname, 1981). The available P was less than 10mgkg^{-1} P considered as adequate for crop production (Agboola and Corey, 1973).

The exchangeable K, Ca, Mg and Na were lower than 0.2mmol/kg critical levels considered as adequate for kola and coconut seedlings respectively (Folorunso et al., 1995), thus, indicating poor soil fertility. The soil bulk density is high (1.60 mgm^{-3}).

Chemical composition of the organic materials

In table 2, poultry manure had the highest values of N and P nutrients and least C/N ratio of 7.08 compared to others. The oil palm bunch had the highest K, Ca and Mg values compared to poultry manure, turkey manure and spent grain respectively.

Effects of organic fertilizers on the growth parameters of bitter kola seedlings

Plant height, stem girth, leaf area, leaf number and shoot weight (growth parameters) of bitter kola seedlings increased significantly ($P<0.05$) under different organic fertilizer treatments compared to the control treatment (Table 3).

Considering the oil palm bunch ash (sole) as reference, amended oil palm bunch ash + poultry manure increased the plant height, leaf area, stem girth, number of leaves and fresh shoot weight of bitter kola seedlings by 82%, 60%, 75%, 89% and 20% respectively. The spent grain + poultry treatment increased the plant height, leaf area, stem girth, number of leaves and fresh shoot weight by 27%, 40%, 27%, 14% and 35% compared to the poultry manure treatment.

When compared to the NPK 15-15-15 fertilizer, oil palm bunch ash + poultry manure treatment increased the plant height, leaf area, stem girth, number the plant height, leaf area, stem girth, number of leaves and fresh shoot weight by 40%, 50%, 45%, 53% and 29%. The aforementioned parameters were also increased by 46%, 50%, 40%, 48% and 38% respectively compared to the sole form of spent grain.

Among the supplemented forms of oil palm bunch ash and spent grain with poultry and turkey manures, oil palm bunch ash + poultry manure treatment increased consistently the plant height, leaf area, stem girth and number of leaves of bitter kola except in fresh shoot weight where oil palm bunch ash + turkey manure had the highest value followed by spent grain + turkey manure and oil palm bunch ash + poultry manure respectively.

The correlation (r) values among the growth parameters were positive and significant at ($P<0.01$) (Table 4). For instance, 'r' values between plant height and shoot weight, shoot weight and leaf area, plant height and number of leaves were 0.868, 0.784 and 0.967 respectively at 1% level.

Table 1. Chemical analysis of the soil before planting bitter kola seedlings.

Soil parameters	Values
Soil pH (H_2O)	5.80
Soil pH 0.01M $CaCl_2$	5.30
Organic matter (%)	0.43
Nitrogen (%)	0.07
Available P (mg/kg)	5.84
K^+ (mmol/kg)	0.14
Ca^{2+} (mmol/kg)	0.11
Mg^{2+} (mmol/kg)	0.09
Na^+ (mmol/kg)+H^+ (mmol/kg)	4.30
Al^{3+} (mmol/kg)	1.49
Fe (mg/kg)	8.5
Zn (mg/kg)	3.8
Mn (mg/kg)	1.84
Cu (mg/kg)	2.2
Sand (%)	79. 60
Silt (%)	14.70
Clay (%)	5.70
Bulk density (mgm^{-3})	1.60
% Porosity	41.81

Table 2. Chemical analysis of the organic residues used for raising bitter kola seedlings.

Organic Materials	C	N	C/N	Total P	K	Ca	Mg	Fe	Zn	Cu
	%		ratio	mg/kg		%			mg/kg	
Poultry manure	32.10c	4.53d	7.08a	385.0d	0.97c	0.32c	0.41b	37.85c	1.69c	0.16b
Oil palm bunch ash	10.40a	1.76b	10.45c	110.20b	2.10d	0.93d	0.70c	50.5d	1.83d	0.64c
Turkey manure	20.20b	2.59c	7.79b	346.20c	0.79b	0.21b	0.18a	29.1b	1.16b	0.14b
Spent grain	10.00a	0.78a	12.82d	76.00a	0.56a	0.13a	0.18a	13.4a	0.7a	0.1a

Treatment means within each column followed by the same letters are not significantly different from each other using Duncan Multiple Range Test (DMRT) at 5% level.

Table 3. The values of growth parameters of bitter kola seedlings under different organic fertilizers.

Treatments	Plant height (cm)	Leaf area (cm^2)	Stem Girth (cm)	Number of leaf	Shoot weight (kg)
Control (no fertilizer)	6.21a	16.61a	0.5a	2.62a	0.40a
NPK 15-15-15	10.81c	17.21ab	1.31b	3.10b	1.50c
Spent grain	9.75b	17.23b	1.43c	3.43c	1.30b
Poultry manure	10.41c	17.80ab	1.36b	3.60c	1.60c
Turkey Manure	10.21bc	16.16a	1.33b	3.54c	1.64cd
Oil Palm bunch ash	9.92b	21.53c	1.36b	3.50c	1.75d
Spent grain+turkey manure	12.21d	24.22d	1.80d	4.40d	2.10e
Spent grain+ poultry manure	14.11e	29.37e	1.85e	4.52d	2.43f
Oil palm bunch ash+ poultry manure	18.01fg	34.50f	2.38f	6.62fc	2.10e
Oil palm bunch ash+ turkey manure	17.21f	32.10f	2.10e	6.31e	2.83g

Treatment means within each column followed by the same letters are not significantly different from each other using Duncan Multiple Range Test (DMRT) at 5% level.

Table 4. Correlation coefficients (r) among the growth parameters of bitter kola under different organic fertilizers.

Parameters	r values
Plant height vs. leaf area	0.924**
Plant height vs. Stem girth	0.960**
Plant height vs. Number of leaves	0.967**
Plant height vs. Shoot weight	0.868**
Leaf area vs. stem girth	0.864**
Leaf area vs. Number of leaves	0.938**
Leaf area vs. shoot weight	0.784**
Shoot weight vs. stem girth	0.885**
Shoot weight vs. Number of leaves	0.792**
Number of leaves vs. stem girth	0.915**

Significant at 1% level

Effects of organic fertilizers on the leaf mineral composition of bitter kola seedlings

The leaf mineral composition of bitter kola seedlings under different organic fertilizer treatments is presented in table 5, and there were significant increases ($P<0.05$) in leaf N, P, K, Ca and Mg compared to the control treatment.

Oil palm bunch ash + poultry manure treatment increased the leaf N, P, K, Ca and Mg of bitter kola seedlings by 16.4%, 50%, 8%, 99.4% and 99.3% respectively compared to NPK 15-15-15 fertilizer treatment. It also increased the leaf N, P, K, Ca and Mg of bitter kola by 52%, 27%, 44%, 37% and 51% respectively compared to the sole form of poultry manure.

Among the sole treatments, the poultry manure treatment increased leaf P, K, Ca and Mg by 40%, 31%, 16% and 18% respectively compared to spent grain treatment except in leaf N where spent grain increased the parameter by 27% compared to poultry treatment.

The leaf K/Ca and K/Mg ratios were 145.1 and 193.1 under NPK 15-15-15 fertilizer treatment compared to K/Ca (1:1) and K/Mg (1:2) under spent grain + poultry manure.

Among the amended treatments, oil palm bunch ash + poultry manure increased consistently the leaf N, P, K, Ca and Mg compared to spent grain + poultry manure, spent grain + turkey manure and oil palm bunch ash + turkey manure respectively.

The correlation (r) values between leaf N, P, K, Ca and Mg and growth parameters of bitter kola seedlings were positive and significant at ($P<0.01$) level, (Table 6), signifying the importance of the positive relationship between nutrient uptake in the leaves and growth parameters of bitter kola seedlings. For instance, 'r' values between leaf N and shoot weight, leaf P and stem girth, leaf Ca and number of leaves were 0.76, 0.798 and 0.721 respectively at 1% level.

Table 5. The values for the bitter kola leaf nutrients (%) under different organic fertilizers at 21 weeks after transplanting (WAP) in the nursery.

Treatments	N	P	K	Ca	Mg
Control (no fertilizer)	0.03a	0.014a	0.02a	0.03b	0.005b
NPK 15-15-15	1.94e	0.26bc	0.58h	0.004a	0.003a
Spent grain	1.51e	0.23b	0.24b	0.36h	0.18b
Poultry manure	1.10f	0.38e	0.35d	0.43f	0.22c
Turkey manure	1.74d	0.29e	0.26b	0.30c	0.32d
Oil palm bunch ash	0.90b	0.31cd	0.29c	0.46fg	0.42f
Spent grain+turkey manure	2.21fg	0.38e	0.42f	0.44f	0.32d
Spent grain+poultry manure	2.18f	0.40ef	0.45g	0.40e	0.38e
Oil palm bunch ash+ poultry manure	2.32g	0.52g	0.63i	0.68h	0.45g
Oil palm bunch ash+ turkey manure	1.85de	0.24b	0.38e	0.41e	0.23c

Treatment means within each column followed by the same letters are not significantly different from each other using Duncan Multiple Range Test (DMRT) at 5% level.

Table 6. Correlation coefficients (r) between leaf minerals composition and growth parameters of bitter kola seedlings under different organic fertilizers.

	Leaf mineral composition				
	N	P	K	Ca	Mg
Growth Parameters					
Plant height	0.764*	0.678*	0.742*	0.670*	0.552*
Number of leaves	0.632*	0.591*	0.59*	0.721*	0.563*
Leaf area	0.58*	0.57*	0.58*	0.672*	0.593*
Stem girth	0.843***	0.798***	0.768***	0.78*	0.671*
Shoot weight	0.76*	0.650*	0.634*	0.623*	0.671*

* Significant at 5% level ** Significant at 1% level

Effect of organic fertilizers on soil chemical properties after removing bitter kola seedlings

The organic fertilizers increased the soil N, P, K, Ca, Mg pH and O.M significantly ($P<0.05$) relative to the control treatment (Table 7).

Oil palm bunch ash + poultry manure treatment increased the soil pH, O.M, N, P, K, Ca, Mg and Na by 28%, 92%, 26.3% 99%, 98%, 92% and 93% respectively compared to NPK 15-15-15 fertilizer. However, the NPK 15-15-15 fertilizer increased soil K by 11% compared to the oil palm bunch ash + poultry manure.

The NPK fertilizer treatment decreased the soil pH and O.M content after removing the bitter kola seedlings compared to the initial soil nutrient status. The NPK fertilizer treatment had higher ratios of K/Ca and P/Mg nutrients

interactions, for-instance, the soil K/Ca P/Mg and K/Mg ratios were 132:1, 668:1 and 99:1 respectively in NPK fertilizer treatment compared to K/Ca (2:1), P/Mg (14:1) and K/Mg (2:1) under oil palm bunch ash.

Generally, the supplemented or amended forms of oil palm bunch ash and spent grain with poultry and turkey manures increased the values of soil N, P, K, Ca, Mg, Na and O.M more than their sole application (turkey, poultry manures, spent grain and oil palm bunch ash).

Among the sole forms of the treatments, oil palm bunch ash had the highest values of soil pH, K and Mg while poultry manure treatment had highest values of soil O.M, N, P and Ca. Turkey manure had higher value of soil Na.

The correlation (r) values between soil N, P, K, Ca, Mg, N, soil pH and O.M and growth parameters of bitter kola seedlings were positive and significant ($P<0.01$ and 0.05) signifying the importance of soil nutrients in improving growth parameters of oil palm seedlings (Table 8).

In-addition, most of the correlation (r) values between soil nutrients and leaf mineral composition of bitter kola seedlings were also positive and significant at 1% and 5% levels (Table 9) For instance, 'r' values between leaf P and soil O.M., leaf N and soil P, leaf K and soil P were 0.78, 0.913 and 0.89 respectively at 1% level.

The non significant (r) values between leaf Ca and soil K, leaf K and soil Mg, leaf K and soil pH showed the evidence of nutrient imbalance which affected the uptake of the nutrients by the crop.

Table 7. The mean soil chemical composition used for bitter kola seedlings aft or experiment under different organic fertilizers.

Treatments	Soil PH	O.M	N	Available P	Exchangeable Cations			
	(H_20)	%		mg/kg soil	K	Ca	Mg	Na Mmol /kg
Control(no fertilizer)	5.30a	0.32a	0.03a	3.14a	0.05a	0.07a	0.09a	0.11a
NPK 15-15-15	5.10a	0.28a	0.37h	26.70e	3.95g	0.03a	0.04a	0.08a
Spent grain	6.31b	1.63b	0.14b	21.65b	2.42b	1.10b	0.75b	0.62b
Poultry manure	6.50b	2.35c	0.26e	24.52d	2.62bc	2.12d	1.27c	0.62b
Turkey manure	6.70c	2.26c	0.21c	22.68bc	2.53b	1.98cd	1.34cd	0.70c
Oil palm bunch ash	6.90cd	2.30c	0.24d	20.56d	3.28e	1.79c	1.42d	0.64b
Spent grain+turkey manure	6.60bc	2.63d	0.30g	30.53f	2.88d	3.42e	1.55de	0.82d
Spent grain + poultry manure	6.70c	2.87e	0.28f	27.80e	2.43b	3.65f	1.84f	1.18g
Oil palm bunch ash + poultry manure	7.10d	3.43f	0.38h	37.24h	3.50f	3.92g	2.15h	1.10f
Oil palm bunch ash+ turkey manure	6.40b	2.88e	0.32g	31.03f	2.62bc	2.07cd	2.02g	0.90e

Treatment means within each column followed by the same letters are not significantly different from each other using Duncan Multiple Range Test (DMRT) at 5% level.

Table 8. Correlation coefficients (r) between soil nutrients composition after experiment and growth parameters of bitter kola seedlings under different organic fertilizers.

Growth parameters	pH	O.M	N	P	K	Ca	Mg	Na
Plant height	0.526*	0.761*	0.774 *	0.873 *	0.517 *	0.707 *	0.807**	0.765**
Number of leaves	0.565*	0.787**	0.635*	0.775*	0.358 ns	0.705*	0.833**	0.762*
Leaf area	0.53*	0.749*	0.594*	0.689*	0.287ns	0.740*	0.811**	0.782*
Stem girth	0.657*	0.787**	0.943**	0.623*	0.623*	0.796**	0.846**	0.833**
Shoot weight	0.593*	0.793**	0.75*	0.839**	0.562*	0.712*	0.841*	0.793**

* Significant at 5% level, **Significant at 1% level, ns Not Significant

Table 9. Correlation coefficients (r) between bitter kola leaf mineral composition and soil nutrients after the experiment under different organic fertilizers.

	pH	O.M	N	P	K	Ca	Mg	Na
Leaf N	0.408ns	0.57*	0.804**	0.913**	0.702*	0.65*	0.565*	0.635*
Leaf P	0.735*	0.78**	0.762*	0.857**	0.713*	0.842**	0.727*	0.741*
Leaf K	0.252ns	0.42 ns	0.957*	0.890**	0.844**	0.50 ns	0.42 ns	0.42 ns
Leaf Ca	0.936**	0.937**	0.427ns	0.668*	0.39 ns	0.854**	0.893**	0.862**
Leaf Mg	0.984**	0.897**	0.39 ns	0.573	0.40 ns	0.865**	0.872**	0.872**

* Significant at 5% level, ** Significant at 1% level, n.s.Not Significant

Discussion

The least values of growth parameters of bitter kola seedlings, leaf and soil N, P, K, Ca, Mg, pH and O.M in the control treatment might be traced to the initial poor nutrient status of the soil and continuous cultivation without fertilization. Therefore, the bitter kola seedlings were having deficiency symptoms of yellow and purple colourations and the marginal burn of leaves consistent with N, P, K or Mg deficiencies.

This observation agreed with the work of Adepetu *et al* (1978) which reported an approximate 58% drop in soil O.M over seven years of continuously cultivating an Iwo soil association in the greenhouse and under field conditions. Hence, this finding corroborates the importance of fertilizer use and application of organic fertilizers to the enhancement of crop productivity in the tropics.

The effectiveness of spent grain and oil palm bunch ash in improving the growth, soil and leaf mineral composition of bitter kola seedlings, when mixed with poultry and turkey manures (i.e. animal manures) can be attributed to enhancement of their degradation rate by the manure with lower C/N ratio. However, the processing of the organic fertilizers before application to the soil should have further enhanced their decomposition and rate of nutrient release to the soil.

This observation might be responsible for the exceptional difference in the performance of the spent grain, oil palm bunch ash supplemented or amended with poultry and turkey manure compared to the work of Adebayo and Olayinka

(1984) which used the unprocessed forms of oil palm bunch ash and sawdust amended with poultry and turkey manures to grow maize.

The better performance of oil palm bunch ash + poultry manure treatment in increasing the plant height, leaf area, stem girth, number of leaves and shoot weight compared to the NPK 15-15-15 fertilizer could be traced to their rich nutrient content (N, P, K, Ca and Mg) which increased the soil nutrient and consequently improved nutrient and water uptake in the plants. The same trend of performance was observed for the leaf N, P, K, Ca, Mg and soil N, P, K, Ca, Mg, pH and O.M as noticed in the significant 'r' values between shoot weight and soil N, plant height and soil P, leaf area and soil Ca, leaf N and shoot weight respectively.

The application of NPK 15-15-15 fertilizer at 400kg/ha has led to high soil K/Ca, K/Mg and Ca/Mg ratio which made difficult the availability of nutrients such as K, Ca, Mg and others to crops as observed in the non significant r values between leaf Ca and soil K, leaf K and soil Mg. This could be responsible for the lower values of soil, Ca, Mg, O.M and P compared to the treatments of spent grain and oil palm bunch ash amended with poultry and turkey manures.

The finding is further supported by Agboola (1982) who reported that arbitrary use of inorganic fertilizers resulted in signs of toxicities, poor yield responses and serious deterioration of soil properties.

The contribution of the organic fertilizers used, in increasing the growth parameters of bitter kola, leaf N, P, K, Ca, Mg, Soil N, P, K, Ca, Mg, pH and O.M was also confirmed by the positive and significant "r" values at 1% and 5% levels between growth parameters, soil and leaf nutrients in bitter kola seedlings.

The striking performances of the amended spent grain and oil palm bunch ash with poultry and turkey manures over their sole forms, was due to the fact that turkey and poultry manures have high nutrient content and low C/N ratios and their combination with spent grain and oil palm bunch ash fortified their nutrient supplying power.

This observation explained the superiority in the growth parameters, of leaf and soil chemical composition of bitter kola seedlings in the oil palm bunch ash amended with poultry manure treatment compared to their sole application. This was in line with Moyin-Jesu (2003) who reported nutrient superiority of organically amended fertilizers over their sole forms in amaranthus (A. Cruentus, NH84/445).

However, it was observed that, the performance of amended oil palm bunch ash + poultry manure treatment in increasing the growth, soil and leaf parameters of bitter kola seedlings was different from the work of Emede et al. (2002) which used sawdust amended with poultry manure to grow amaranthus (A. Cruentus, NH84/445). This difference might be due to the higher nutrient composition and lower C/N ratio of oil palm bunch ash than saw dust.

The increase in soil pH under oil palm bunch ash or the amended form with the poultry manure compared to other treatments, was traced to its high K, Ca and Mg contents, and could be effective as a liming materials (Gordon, 1998) unlike the NPK 15-15-15 fertilizer which with continuous use could decrease soil pH.

The soil pH had been reported to influence nutrient uptake and availability. Obatolu (1995) reported that oil palm bunch ash, wood ash and cocoa pod husk improved K, Ca and Mg nutrients and corrected soil acidity in an Alfisol grown to coffee and maize.

The higher values of plant height, leaf area, stem girth and number of leaves, leaf and soil N, P, K, Ca, Mg, pH and O.M in the oil palm bunch ash + poultry manure treatment compared to oil palm

bunch ash + turkey manure, spent grain + poultry manure and spent grain + turkey manure treatments could be traced to the fact that poultry manure had the highest values of N, P, nutrients and least C/N ratio while oil palm bunch ash had the highest amount of K, Ca, Mg, Fe, Zn and Cu nutrients.

This observation was similar to the work of Moyin-Jesu (2007) who reported the performance of oil palm bunch ash + poultry manure in increasing the growth, leaf and soil nutrients in coffee seedlings.

The exceptional increase in leaf N under spent grain compared to poultry manure treatment could be as a result of its improvement in soil physical property (i.e. bulk density reduction). Moyin-Jesu and Ojeniyi (2006) reported that spent grain reduced most the soil bulk density compared to wood ash, cocoa husk, rice bran and saw dust, although, it has relatively lower nutrient composition.

This unique attribute of spent grain in improving soil physical condition might have enhanced reduction in soil compaction and made root penetration easier, thus allowing greater uptake of N in the leaf and probably be responsible for the second best performance in shoot weight of bitter kola when it was amended with turkey manure. N is reported by Ojeniyi (1984) to increase the root and shoot parameters of plants.

Conclusions and Recommendations

The sole and amended forms of oil palm bunch ash and spent grain with poultry and turkey manures applied at 8t/ha (40g/pot) increased the soil, leaf N, P, K, Ca, Mg, soil pH and O.M., plant height, stem girth, leaf number, leaf area and shoot weight of bitter kola seedlings. It is recommended that amended oil palm bunch ash + poultry manure (8t/ha) was the most effective fertilizer materials for improving the nutrient availability and ensuring sustainable cultivation of bitter kola seedlings on a commercial basis.

This recommendation agreed with the fact that inorganic fertilizers are becoming very expensive to purchase by small holding farmers of bitter kola. These materials appear to also have beneficial secondary effects on soil properties and could be more favourable to the environment.

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