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Evaluation of the effectiveness of goat dung manure and kola pod husk ash on nutrient composition and growth performance of coffee (*Coffea arabica*) in Nigeria

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ABSTRACT

Objective: The objective of the study was to determine the effectiveness of sole and combined application of goat dung manure and kola pod husk ash on the growth, nutrient composition of coffee seedlings and the soil chemical composition.

Methodology and Results: Two organic fertilizer treatments; kola pod husk ash (KPHA) and Goat dung (GD) were applied at 6.5g KPHA (5t/ha), 25g GD (20t/ha), 25g GD + 6.5g KPHA (20t/ha + 5t/ha), 18.75g, GD + 6.5g KPHA (15t/ha + 6.5t/ha). The treatments were also applied at 12.5g GD + 6.5g KPHA (10t/ha + 5t/ha), 6.5g GD + 6.5g KPHA (5t/ha + 5t/ha) along with a treatment of 0.6g urea (400 kg/ha), per 2.5kg of soil filled polythene bag and the control. The test soil was low in organic matter (OM), pH, Nitrogen, Phosphorous, Potassium, Calcium, Magnesium and Manganese. Kola pod husk ash (KPHA) had higher pH, OM, N, P, K, Na, Mg and Ca concentrations compared to Goat dung (GD) manure. The results showed that the organic fertilizers increased significantly ($P<0.05$) the plant height, number of leaves, stem girth, number of branches, leaf area, root and shoot lengths, root and shoot fresh weights, root and shoot dry weights, soil and leaf N, P, K, Ca, Mg, Na, soil pH and OM compared to the control treatment. When compared with urea fertilizer treatment, both sole and combined applications of GD and KPHA increased growth parameters of the coffee seedlings and both soil and leaf chemical compositions. Among the organic manure treatments applied, inconsistent trends were obtained among 20t/ha GD+5t/ha KPHA, 10t/ha GD + 5t/ha KPHA, 5t/ha GD + 5t/ha KPHA and sole application of 5t/ha KPHA. 5t/ha GD + 5t/ha KPHA increased plant height, stem girth, leaf area, number of leaves, number of branches, root and shoot lengths, fresh and dry root weights, fresh and dry shoot weights of coffee seedlings by 30%, 28%, 64%, 33%, 8%, 76%, 68%, 67%, 78%, 22%, and 48%, respectively compared with urea fertilizer treatment. 5t/ha GD + 5t/ha KPHA was the most effective treatment in improving coffee growth parameters, leaf and soil chemical composition.

Conclusion and application of result: Combined application of GD and KPHA manures applied at 5t/ha GD+5t/ha KPHA increased the soil, leaf N, P, K, Ca, Mg, soil pH, OC, OM and the growth parameters of

coffee seedlings compared with other combinations, KPHA or urea alone. The combination is recommended for optimum growth of coffee seedlings.
Keywords: Coffee, Goat dung, Kola pod husk ash, Nutrient composition, Growth parameters

INTRODUCTION

Coffee belongs to the family Rubiaceae and the genus coffee. There are more than 70 species of coffee but only two are economically important and planted by farmers in Nigeria (Coffea *arabica* L*, and Coffea canephora.* Pierre) (Williams 1989).

However, coffee production and quality of berries in Nigeria are facing serious challenges because of scarcity of new coffee seedlings to replace the ageing and non productive coffee stock in the field. Replacement is becoming difficult due to the cumbersome procedure of raising young coffee seedlings in the pre-nursery and nursery stages and the continued decline in soil fertility (Moyin – Jesu 2007). Coffee like other tree crops requires high soil fertility status especially with respect to soil organic matter and available Nitrogen (N). Other nutrients such as P, K, Mg and micronutrients are essential for coffee production. In Nigeria continuous raising of coffee in the pre-nursery and nursery in sandy loam soil usually result in poor growth, chlorosis and other nutrient deficiency symptoms typical of N, P, K, Ma, Ca in the crop. Moyin – Jesu (2007) observed that situation is more apparent if organic manure is not applied. Because of high cost and unavailability of chemical fertilizers to the majority of coffee growers, there is high dependence on local cheap organic sources for maintaining soil fertility. However, the current use of some of these organic nutrient sources such as goat dung and kola pod husk ash by the coffee farmers is not based on research findings. Moyin–Jesu, (2002) reported that residue mulch materials including grasses, other weeds and farm wastes were efficient in improving the soil nutrient status in coffee plantations. Obatolu (1995) reported the use of cocoa pod husk as fertilizer for coffee and maize production while Folorunso (1999) also reported the use of 22 different sole and amended plant residues for the growth, pod yield, leaf yield and soil fertility improvement for okra and Amaranthus crops respectively. However there is scarcity of research information on use of goat dung manure and kola pod husk ash on nutrient composition and growth performance of coffee seedlings.

The objective of the study was to determine the effectiveness of sole and combined application of goat dung manure and kola pod husk ash on the growth and nutrient composition of coffee seedlings and soil chemical composition.

MATERIALS AND METHODS

The trial was conducted between 2009 to 2010 in Ibadan, in the rain forest zone of south west Nigeria. The site was located at Cocoa Research Institute of Nigeria (CRIN), Ibadan. Goat dung manure used for the experiment was obtained from near by pen in Akure, Ondo state. While kola pod husk was obtained from kola processing unit of CRIN. Also, viable and disease free coffee berries were collected from the coffee experimental plot of Cocoa Research Institute of Nigeria (CRIN). The experimental design was randomized complete block (RCBD) replicated three times. Two organic fertilizer treatments namely kola pod husk ash (KPHA) and Goat dung (GD) were applied. This was at 6.5g KPHA (5t/ha), 25g GD (20t/ha), 25g GD + 6.5g KPHA (20t/ha + 5t/ha), 18.75g, GD + 6.5g KPHA (15t/ha + 6.5t/ha), 12.5g GD + 6.5g KPHA (10t/ha + 5t/ha), 6.5g GD + 6.5g KPHA (5t/ha + 5t/ha) along with a reference treatment of 0.6g urea (400 kg/ha). This was per 2.5kg of soil filled polythene bag respectively and the control.

Pre-Nursery and Nursery Establishment: In January 2009, air-dried beans were sown in wooden boxes (90x60x30cm) previously filled with saw dust. The bean boxes were thoroughly watered, mulched and kept under shade. The watering continued every day in the morning and evening for twelve (12) weeks until the rains became steady. The seeds germinated about 7 weeks after sowing. For nursery establishment, soil

taken from 0-15cm depth was sieved and 2.5kg placed into a polythene bag (25cm x 13cm) the germinated coffee seeds were transplanted in to the polythene bags. Watering was done immediately to prevent transplanted seedlings from wilting and this continued for one week till proper establishment. A shade was provided over the polythene bags containing the germinated seeds to prevent scorching by sun. KPHA was sun dried for 3 weeks then burnt to ashes. After cooling, the ash collected and goat dung were applied on soil surface by spot method four weeks after transplanting.

Soil Analysis: Surface (0 – 15cm) soil used for the study was analyzed after bulking core samples. The bulked sample was taken to the laboratory, air–dried and sieved to pass through a 2 mm screen for chemical analysis. Also analysis of soil collected for treatments at 24 weeks after transplanting was done.

The soil PH (1:1 soil / water) was read on the pH meter. Organic matter was determined by the wet oxidation method (Moyin – Jesu, 2007). Soil P was extracted and measured by the Murphy blue coloration and determined on a spectronic 20 at 882um. Exchangeable soil K, Ca and Mg were extracted with 1M Ammonium Acetate (NH_4OAC), pH, K and Ca was determined with flame photometer, Mg determined with an atomic absorption spectrophometer and the total N determined by the micro Kjedahl Method (AOAC, 1990). Mechanical analysis of the test soil was done using hydrometer method.

Data Analysis: The growth parameters such as plant height, leaf area, number of leaves, stem girth and number of branches were recorded from 4 weeks after transplanting (WAT). Hand weeding was done 4, 8, 12, 16, and 20 weeks after planting. At 24 weeks after planting in the nursery, the seedlings were carefully removed from the polythene bags for the measurement of fresh root and shoot weights, thereafter dried for determination of dried and shoot weights. The tissues were analyzed for N, P, K, Ca, and Mg content after wet digestion by acid mixture (AOAC, 1990). The organic fertilizer materials were also analyzed for macro and micro nutrients.

Statistical Analysis: The growth and yield data collected in 2009 were analyzed using ANOVA. The treatments were compared using Duncan's Multiple Range Test (P=0.05).

RESULTS AND DISCUSSION

The physio-chemical properties of the soils are presented in Table 1. The results showed that, the soil was acidic and low in organic matter, based on the established critical levels for the soils in south west Nigeria (Agboola and Corey, 1973). The soil nitrogen (N) was less than 0.15% which is considered optimal for most crops (Sobulo and Osiname, 1981). Also, the available P was less than 10mg/kg which is considered as adequate for crop production (Agboola, 1982). The exchangeable K was more than 0.2 cmol/kg which is considered optimal for most crops. Again, the levels of Ca and Mg were very low indicating poor soil fertility. The soil was texturally sand loam, belonging to Onigambari series and an Alfisol (Soil Survey Staff 1999).

Table 1: Physio-chemical characteristics of the soils of experimental site before planting coffee seedlings.

Soil properties	Value	Exchangeable Bases	Value
Physical properties		K^+	0.52 cmol/kg
Sand	542.02g/kg	Ca^{++}	0.50 cmol/kg
Silt	130.56g/kg	Na^+	0.98 cmol/kg
Clay	149.55g/kg	Mg^{++}	2.80 cmol/kg
Textural class	Sand loam	Mn^{++}	0.03 cmol/kg
Chemical properties		**Exchangeable Acidity**	
pH (H_20) 1:1	5.16	AL^{+++}	0.23 cmol/kg
Organic carbon	2.63g/kg	H^+	0.12 cmol/kg
Organic matter	0.56%	ECEC	5.14 cmol/kg
Total Nitrogen	0.05g/kg	Base Saturation	82%
Available Phosphorus	2.00mg/kg		

The chemical analysis of the organic fertilizer materials used for growing coffee seedlings is presented in Table 2. KPHA had higher concentration of N, P, K, Na, Mg and Ca. Where as GD had higher C: N and organic matter (OM). The higher P, K, Na, Mg, Ca and pH for KPHA agreed with the fact that plant derived ash including those of cocoa and kola pod husk increased P, K, Ca, Mg, soil pH and yield of vegetables, rice, millet and maize (Owolabi *et. al*., 2003).

Table 2: Chemical Analysis of the Organic Fertilizers used for the Experiment

Treatment	pH H_2O	C/N Ratio	OM %	N %	P Mg/kg	K Mg/L	Na Mg/L	Mg Mg/L	Ca Mg/kg
Goat dung	6.38	62	4.8	1.26	16.36	2.29	1.67	1.90	3.40
Kola pod husk ash	8.21	10.00	2.8	3.26	32.62	3.93	2.19	3.80	6.90

The organic fertilizers increased significantly ($P<0.05$) the plant height, number of leaves, stem diameter, number of branches, leaf area, root and shoot lengths, root and shoot fresh weights, root and shoot dry weights of coffee seedlings compared to the control or the area fertilizer used. For instance, 5t/ha GD+ 5t/ha KPHA increased the above mentioned growth parameters of coffee seedlings by 30%, 28%, 64%, 33%, 8%, 76%, 68%, 67%, 78%, 22%, and 48%, respectively compared with urea fertilizer treatment. (Table 3 & 4). The significant increases in growth parameters could be cited for the nutrient contents of the combination of both GD and KPHA used which encouraged better seedling growth. This finding that the manure (5t/ha GD + 5t/ha KPHA) improved the growth of coffee seedlings is consistent with earlier finding of Adeniyan and Ojeniyi (2005) and Moyin–Jesu (2007) who reported that organic manure supported crop growth performance and increased crop yield. Hence the need for GD can be reduced by adding KPHA. Also, urea alone increased the growth parameters of coffee seedlings relative to the control treatment (Tables 3 & 4).

Table 3: The growth parameters of coffee seedlings between 4 – 24 weeks after transplanting from pre-nursery under different levels of kola pod husk ash and goat dung manure application

Treatment	Plant height (cm)	Stem girth (cm)	Leaf area (cm)	Number of leaves	Number of branches	Root length (cm)	Shoot length (cm)
5t/ha KPHA	20.14b	0.35a	30.88a	12.93a	1.21b	6.93d	8.91d
20t/ha GD	14.98b	0.21ab	16.67cd	11.07ab	1.02b	11.80bc	13.17c
5t/ha GD+5t/ha KPHA	26.71a	0.37a	33.94a	13.20a	1.10ab	16.13a	19.32a
15t/haGD +5t/ha KPHA	16.71b	0.30ab	27.06ab	12.20a	2.13a	12.73b	15.71b
10t/haGD +5t/ha KPHA	15.75b	0.22ab	12.64cd	12.46a	2.00a	11.80bc	14.32bc
20t/ha GD+5t/ha KPHA	19.45ab	0.29ab	36.89a	13.00a	2.13a	12.73b	15.63b
Urea 400kg/ha	18.64b	0.27ab	21.65bc	8.80b	1.01b	4.01d	6.1d
Control	14.64b	0.17b	9.05d	4.00c	0.22c	4.20d	6.20d

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

Table 4: The yield parameters of coffee seedlings 24 weeks after transplanting under different levels of kola pod husk ash and goat dung application

Treatment	Fresh root weight (cm)	Dry root weight (cm)	Fresh shoot weight (g)	Dry shoot weight (g)
5t/ha KPHA	4.33ab	2.33ab	15.43ab	6.33a
20t/ha GD	3.00ab	1.66b	11.00bc	4.33b
20t/ha GD + 5t/ha KPHA	5.00a	3.00ab	15.00ab	8.33a
15t/ha GD + 5t/ha KPHA	4.66ab	2.33ab	13.33b	4.33b
10t/ha GD + 5t/ha KPHA	4.33ab	3.33a	15.33ab	6.33a
5t/ha GD + 5t/ha KPHA	5.66a	3.66a	17.00a	6.66a
Urea 400kg/ha	1.66c	0.66b	11.66bc	4.33b
Control	0.33c	0.11c	2.00d	1.00d

Treatment means within each column followed by the same level are not significantly different from each other using Duncan in multiple ranges Test at 5% level.

There were significant increases ($P<0.05$) in soil Ph, N, P, K, Ca, Mg, OC, Na and OM compared to the control treatments under different organic fertilizer treatments (Table 5). 20t/ha GD + 5t/ha KPHA had the highest values of soil Ph, OC, and OM followed by 10t/ha GD +5t/ha KPHA while combination of 5t/ha GD + 5t/ha KPHA gave the highest values of soil N, P, Na, Ca and Mg compared to other treatment applications. For example, 5t/ha GD + 5t/ha KPHA increased the soil Ph, OC, OM, N, P, K, Na, Mg and Ca by 15%, 2% 28%, 41%, 71%, 2%, 8%, 31% and 45% respectively compared to urea fertilizer treatment. Therefore, it is ascertained that KPHA increased availability of OM, N, P, K and the cations in the soil and that its use along with GD served to reduce soil acidity and increased availability of nutrient in the soils.

Table 5: Soil chemical analysis after experiment under different levels of kola pod husk ash (CPHA) goat dung manure

Treatment	Soil pH (H_2O) 1:1	Organic carbon (OC) g/kg	Organic matter %	N %	P Mg/kg	K Mg/L	Ma Mg/L	Mg Mg/L	Ca Mg/L
5t/ha KPHA	5.90^{a}	2.62^{e}	1.02^{e}	0.72^{b}	7.07^{d}	0.60^{e}	0.65^{d}	1.80^{c}	0.40^{f}
20t/ha GD	5.13^{b}	1.38^{f}	2.38^{d}	0.30^{e}	14.56^{b}	0.84^{d}	0.74^{c}	1.30^{d}	3.10^{c}
20t/ha GD + 5t/ha KPHA	6.01^{a}	3.32^{a}	5.60^{a}	0.32^{e}	8.54^{c}	0.79^{d}	0.69^{d}	1.80^{bc}	4.70^{b}
15t/ha GD + 5t/ha KPHA	5.28^{b}	2.87^{c}	4.95^{b}	0.38^{d}	6.51^{d}	2.21^{a}	1.17^{b}	2.00^{b}	4.30^{c}
10t/ha GD + 5t/ha KPHA	5.93^{a}	2.95^{b}	5.00^{a}	0.48^{c}	8.80^{e}	1.21^{c}	1.17^{b}	2.30^{b}	5.00^{b}
5t/ha GD + 5t/ha KPHA	5.27^{b}	2.87^{c}	3.95^{c}	0.82^{a}	31.64^{a}	1.36^{b}	1.32^{a}	2.90^{a}	6.60^{a}
400kg/ha Urea	4.03^{c}	2.82^{d}	2.85^{d}	0.48^{c}	9.10^{c}	1.33^{b}	1.03^{b}	2.90^{b}	3.00^{a}
Control	4.26^{c}	0.66^{g}	0.46^{f}	0.28^{f}	2.50^{e}	0.49^{f}	0.22^{e}	0.40^{e}	0.08^{g}

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

Urea alone also increased soil OM, N, P, K, Ma, Mg, and Ca relative to the control. This could be due to enhanced microbial activity (due to surge in N availability) that led to enhanced production and mineralization of organic matter from the source in soil. However, urea reduced soil pH due to its acid producing nature. It was observed (Table 5) that at 5t/ha KPHA application, irrespective of the level of GD,

soil pH, OC, OM, N, P, K, Ca and Mg increased. The increased N availability should have enhanced microbial degradation of GD and KPHA and release of nutrients from them. Previous studies by Odedina *et. al.,* (2003) found that saw dust ash and other plant derived ashes increased soil N, P, K, Ca, and Mg contents. Hence, its combined use with GD in the present work ensured a more balanced nutrition as shown by higher soil OM, N, P, K, Ca and Mg compared to use of urea alone. The use of KPHA along with GD or urea would serve to control soil acidity problem that arises with repetitive use of urea (Adediran *et. al*., 1999). Also, Ojeniyi (1980) reported that long term NPK application significantly influenced nutrient content of coffee plots in south western Nigeria. Ojeniyi (1981) again reported that acidic fertilizers are known to increase uptake of Mn by Arabica coffee. Also, NPK application was reported to increase Cu content in coffee. It was found that combination of 5t/ha GD + 5t/ha KPHA and 20t/ha GD + 5/ha KPHA mostly improved growth and nutrient status of coffee seedlings. Combination of GD and KPHA at 5t/ha GD + 5t/ha KPHA gave highest values of leaf P, K, Mg and Na and relatively high value of leaf N. This is consistent with the fact that organic materials are a natural source of major and micronutrients. The above findings corroborate the need for application of natural source of nutrient in coffee production to ensure balanced nutrition. The highest leaf P, K, Mg, and Na recorded for 5t/ha GD + 5t/ha KPHA was consistent with the work of Folorunso (1999) who reported highest values of leaf N, P, K, Ca, Mg for amended wood ash with animal manure. The urea fertilizer also reduced soil pH and this might be as a result of sorption of NH_4^+ ion on the soil surface. Barber (1962) reported that large application of synthetic fertilizer such as NPK continuously might influence the cation concentration on the soil solution and in the exchange phase, there by, affecting their equilibrium, selectivity and effective diffusion co-efficient.

Table 6: The leaf chemical composition of coffee seedlings under different levels of kola pod husk Ash and goat dung (GD) application

Treatments	N %	P mg/Kg	K Mg/100g	Mg Mg/L	Ca Mg/100g	Na Mg/L
5t/ha KPHA	4.2^{c}	10.3^{c}	7.5^{b}	3.9^{c}	12.7^{e}	3.9^{e}
20t/ha GD	4.7^{b}	10.0^{c}	15.6^{a}	4.3^{bc}	18.4^{b}	6.5^{a}
20t/ha GD + 5t/ha KPHA	5.4^{a}	11.2^{c}	14.0^{c}	8.2^{a}	23.2^{a}	5.3^{cd}
15t/ha GD + 5t/ha KPHA	4.3^{bc}	10.2^{c}	13.2^{d}	3.7^{c}	16.0^{c}	5.0^{d}
10t/ha GD + 5t/ha KPHA	5.2^{a}	11.2^{c}	11.4^{f}	4.8^{b}	16.0^{c}	5.6^{c}
5t/ha GD + 5t/ha KPHA	5.2^{a}	17.3a	14.5b	8.8c	9.6f	6.0b
400kg/ha urea	4.1^{c}	10.3^{c}	10.8^{g}	3.9^{c}	18.4^{b}	5.1^{cd}
Control	2.2^{d}	4.0^{d}	8.8^{e}	2.0^{d}	8.2^{f}	3.0^{e}

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

Application of GD at 20t/ha was the least efficient in the supply of nutrients to coffee seedlings and this may be attributed to the fact that GD had the least nutrient contents compared with KPHA. GD had the least values of N, P, K, Ma, Mg and Ca, therefore, soils treated with this manure had low values of soil OM, N, P, K, pH, and Ca. However, the addition of KPHA to GD increased its nutrient supply power. Combined application of KPHA and GD were the most beneficial for the coffee seedlings than the others because KPHA is more soluble than GD due to its lower C: N (Folorunso 1999). The lower C: N for KPHA compared to GD should have aided nutrient release from KPHA and enhanced release of nutrients such as N, P, K, Mg and Ca which are essential for coffee performance. The synergistic relationship between KPHA and GD is also attributable to quicker dissolution of base and micro nutrients in KPHA compared with GD which has to be decomposed and the organic nutrients mineralized. Ayeni *et. al.*, (2009) found that cocoa pod husk ash (CPHA) and poultry manure (PM) added N, P, K, Mg, Zn, Cu and F when combined with NPK fertilizers. Also the GD is expected to have more residual effect on soil nutrient content and crop yield compared with KPHA and had that advantage when used with KPHA. The

later would have benefited coffee seedlings which is not an annual crop.

CONCLUSION

It was observed from the result that the combined application of GD and KPHA manures applied at 5t/ha GD+5t/ha KPHA increased the soil, leaf N, P, K, Ca, Mg, soil pH, OC, OM and the growth parameters of coffee seedlings compared with other combinations, KPHA or urea alone. The combination is recommended for optimum growth of coffee seedlings. This recommendation was based on the fact that both GD and KPHA were effective sources of macro and micro nutrients.

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