

## Utilization of Agricultural Wastes for the Growth, Leaf and Soil Chemical Composition of Cocoa Seedlings in the Nursery

E.I. MOYIN JESU & B. ATOYOSOYE

*Agronomy Department  
Federal College of Agriculture  
Akure, Ondo State  
Nigeria*

**Keywords:** Wood ash, cocoa pod husk, rice bran, cocoa seedling, nursery, organic residue treatment

### ABSTRAK

*Satu eksperimen mengkaji keberkesanan abu kayu, serbuk kulit, sekam padi dan abu tandan kelapa sawit digunakan biasanya buah koko atau dicampur dengan baja najis itik dan ayam ke atas daun, komposisi kimia tanah dan pertumbuhan anak benih koko di tapak penyemaian, yang dikendalikan di Akure (Lat 7°N', 5°10'E) di zon hutan hujan Nigeria sepanjang tahun 1997 hingga 1999. Sebanyak 12 rawatan sisa organik yang setiap satunya digunakan dalam 30 g per 10 kg tanah (6+/ha) dalam satu polibeg dibanding dengan NPK 15-15-15 (iaitu pembajaan yang dicadangkan) yang menggunakan 2 g per 10 kg tanah (400 kg/ha) dan satu rawatan kawalan. Rawatan-rawatan tersebut diulangi sebanyak empat kali dan diatur dalam pola rawak yang lengkap. Sisa-sisa dan tanah tersebut dianalisis secara kimia sebelum biji-biji benih disemai. Dua biji benih koko (Theobroma cacao (L.)) ditanam dalam setiap polibeg dan dijadikan satu pokok selepas 14 hari. Parameter pertumbuhan seperti ketinggian pokok, kawasan daun, parameter pertumbuhan stem seperti ketinggian pokok, kawasan daun, ukuran lilit stem, seperti ketinggian pokok, kawasan daun, ukuran lilit, pengeluaran daun, akar dan berat sukatan tunas diukur. Kandungan nutrien daun dan pH tanah serta kandungan (organik juga ditentukan). Keputusan-keputusan menunjukkan bahawa rawatan sisa organik secara signifikannya meningkatkan ( $p < 0.05$ ) pertumbuhan pokok, daun, kandungan N, P, K, Ca, Mg dan Na, pH tanah dan ciri-ciri organik meningkatkan pertumbuhan, daun dan nutrien tanah lebih daripada rawatan baja NPK kecuali untuk tanah N dan P. Tanah yang rendah pH apabila dibajakan dengan NPK melambatkan percambahan biji benih koko dan pertumbuhan berikutnya. Di antara rawatan-rawatan sisa tanaman, abu kayu dan abu tandan kelapa sawit meningkatkan kebanyakan kandungan tanah dan nutrien daun serta parameter-parameter pertumbuhan anak benih koko sementara tanah dirawat dengan kombinasi abu tandan kelapa sawit dan baja najis ayam belanda menunjukkan pertumbuhan kandungan daun dan tanah N, P, K, Ca dan Na pH tanah dan kandungan ciri-ciri organik.*

### ABSTRACT

*An experiment investigating the effectiveness of wood ash, cocoa pod husk, rice bran and oil palm bunch ash used ordinarily or in combination with duck and turkey manures on the leaf, soil chemical composition and growth of cocoa seedlings in the nursery, was conducted in Akure (Lat 7°N', 5°10'E) in the rainforest zone of Nigeria during the period of 1997 to 1999. Twelve organic residue treatments, each applied at 30 g per 10 kg soil (6t/ha) in a polybag were compared to the NPK 15-15-15 (i.e recommended fertilization) applied 2 g per 10 kg soil (400 kg/ha) and a control treatment. The treatments were replicated four times and arranged in a completely randomized design. The residues and soils were chemically analyzed before seeds were sowed. Two cocoa seeds (Theobroma cacao (L.)) were planted into each polybag and thinned to one plant after 14 days. The growth parameters such as plant height, leaf area, stem growth parameters such as plant height, leaf area, stem girth, leaf production, root and shoot dry weight were measured. The leaf nutrient contents and soil pH and organic C content were also determined. The results showed that the organic residue treatments significantly increased ( $p < 0.05$ ) the plant growth, leaf N, P, K, Ca, Mg and Na contents soil pH and organic matter (O.M) compared to the control treatment. All the organic residue treatments increased the growth, leaf and soil nutrients more than NPK fertilizer treatment except for soils N and P. The low pH of the soils when fertilized with NPK delayed*

*germination of cocoa seeds and the subsequent growth. Among plant residue treatments, the wood ash and oil palm bunch ash increased most the soil and leaf nutrient contents and growth parameters of cocoa seedlings while the soil treated with the combination of oil palm bunch ash + turkey manure indicated the best of growth, leaf and soil N, P, K, Ca, and Na contents, soil pH and organic matter content.*

## INTRODUCTION

Cocoa (*Theobroma cacao*) originated from the upper amazon region of Latin America and it was introduced into Nigeria from Fernandopo in 1974 (Opeke 1982). Cocoa belongs to the genus *Theobroma* in the family stericulaceae and over 200 species of cocoa are recognised worldwide but all the cultured species belong to the single species *Theobroma cacao*.

Opeke (1982) reported that in Nigeria, cocoa serves as a valuable source of cocoa butter and beverages while the residual cocoa powder is used in cake biscuits, cocoa food, cocoa mixes and other confectioneries. The cocoa pod husk is a good source of organic fertilizer as it improves soil fertility (Adv Dappah *et al.* 1994). Potassium hydroxide when extracted from the husk can be used in soap making. Cocoa is also one of the main sources of foreign exchange earning for Nigeria, Ghana and Cote d'Ivoire (Are 1967).

In spite of the utilization and importance of the crop, the cocoa production in Nigeria is facing serious problems at present, because the trees are ageing and there is a scarcity of new cocoa seedlings to replace about 571, 864 hectares of ageing cocoa trees in the field. This replacement is becoming difficult because there is scarcity of top rich soil to grow young cocoa seedlings in the nursery as a result of urbanisation and deforestation practices coupled with the continued decline in fertility of the field soils. Efforts to supplement the soil fertility through the use of inorganic fertilizers to grow cocoa seedlings are limited by the high cost of purchase, scarcity at the farmers' level and continued deterioration of soil properties (Folorunso *et al.* 1995).

Umoti *et al.* (1990) reported that both cocoa and oil palm were heavy drains of plant nutrients in the nursery and field. High productivity of these could be achieved and sustained by massive application of inorganic fertilizers. However, inorganic fertilizers have become very expensive (N1,500.00 per bag) especially for the low income farmers who constituted the major producers of both palm oil and cocoa in Nigeria. This assertion was further supported by Obatolu (1999) who

reported that 305 kg Urea/ha/yr, 250 kg SSP/ha/year and 80 kg Kd/ha/yr would be required annually for cocoa production either in the nursery or field. Hence, in monetary terms, the cost of the inorganic fertilizers would be colossal. Therefore, the complementary use of organic fertilizer materials derived from the oil palm cocoa production, food crops such as rice, maize, cassava and trees could help to bring down the high cost.

The potentials of oil palm bunch ash, cocoa pod ash, rice bran, wood ash, sawdust duck and turkey manure as sources of fertilizers have been established (Omoti 1989; Ahenkorah *et al.* 1981; Obatolu 1983; Oladokun 1986; Folorunso 1999) in growing maize, cassava, oil palm, coffee and okra crops. The abundance of the cocoa pod husk, oil palm bunch ash, rice bran and wood ash have been established in Nigeria. For instance, Gill and Duffus (1986) reported that about 220,000 metric tones of dry cocoa pod husk were produced in Nigeria and about 60% of it was produced in Akure are of Ondo State, Nigeria. Folorunso (1999) also established the abundance of oil palm ash, rice bran and sawdust in the Akure area of Ondo State, Nigeria because of the rainforest ecology.

There is a scarcity of research information on the use of oil palm bunch ash, cocoa pod husk, rice bran and wood ash, used in ordinary form or in combination with duck manure and turkey manure to grow cocoa seedlings in the nursery and field. Therefore, there is justification to investigate these organic wastes to grow cocoa seedlings in the nursery to replace the old and non productive stock on the field for optimum production as a means of increasing the income base of the farmers and that of producing states by going into large scale production. The objectives of the study were therefore, to investigate the growth performances of cocoa seedlings as influenced by the organic residues applied alone or with duck and turkey manure in the nursery, and to determine the leaf nutrient contents and soil chemical properties of the cocoa seedlings as influenced by the organic residues.

## MATERIALS AND METHODS

The experiment took place at Akure (lat 7°N', 5°10'E) in the rainforest zone of Nigeria during the period of 1997 to 1999.

The annual rainfall is 1300 mm and a temperature of 70°C. The soil is a sandy loam, skeletal, kaolin tic, isohyperthermic toxic paleustalf (Alfisol) or Ferric Luvisol (F.A.O).

### *Source and Preparation of Agricultural Crop Residues*

Cocoa pod husk, woodash, oil palm bunch ash obtained from the cocoa farm plots, cassava processing unit and oil-palm processing unit of Federal College of Akure. The turkey and duck manure were got from livestock units and nearby farms in large quantities. Rice bran was collected from the 05-6 variety processed at College rice mill. The organic residues were processed to allow decomposition. The dried cocoa pod husks were ground using hammer mill while the rice bran was chopped into pieces, wetted and allow to decompose. The turkey and duck manure were stacked to allow for mineralization and placed under shade.

The College has 300 hectares each of cocoa, oil palm plantations from which high quantities of cocoa pod husks and empty oil palm bunches were available. It also had 200 hectares of rice fields from which sizeable quantities of rice bran could be obtained. The livestock unit had 6,000 turkey birds and the nearby farm had 4,000 ducks from which reasonable quantities of turkey and duck manure were collected for growing cocoa seedlings. The processing of tubers from 200 hectares of cassava generated high quantities of wood ash derived from fuel wood and planks purchased from the nearby sawmill. Generally, all the organic residues used were easily available, sustainable and cheap for growing cocoa, oil palm, kola seedlings in commercial quantities.

### *Analysis of the Organic Material Used for the Experiment*

Two grammes of each organic material were weighed into a clean dry tector digestion tube and 25ml of HNO<sub>3</sub> was added down the neck of the flask and swirled to ensure that the organic material was thoroughly wetted. Five millimeters of H<sub>2</sub>SO<sub>4</sub> and HClO<sub>4</sub> were added and the mixtures were swirled again. It was then placed on the digestion block and heated carefully. Digestion continued until the samples were clear

and the acids were completely volatilized. The samples were allowed to cool and 10 ml of distilled water was added. Filtration into a 100 ml volumetric flask was done and the filtrate was left to cool before it was made to the mark with distilled water.

The filtrates collected from 25-5-5 ml HNO<sub>3</sub>-H<sub>2</sub>SO<sub>4</sub> digestion method were used for the determination of % P, K, Ca, Na and Mg by taking an aliquot of the plant digests into a 50 ml volumetric flask. For % P, 20 ml of phospho vanado molybdate solution was added and allowed to stand for at least 2 hours. The color absorbance was measured on spectronic 20 at 442 um. The % K, Ca and Na contents, and an aliquot were measured into a 100 ml flask and diluted. 1 ml of the sample solution was taken, the flame photometer was adjusted, followed by the aspiration of the diluted sample solution. The solution was read in ppm (mg/kg) and later converted to % contents. Mg content was determined using atomic absorption spectrophotometer.

The % nitrogen was determined by weighing 2 g of each organic material into a digestion flask and 5 ml of HNO<sub>3</sub> with selenium and copper-sulphate tablets were added. After addition of sodium hydroxide, the distillate was collected, boric acid was added with an indicator before it was titrated with 0.1M dil HCL.

### *Soil Analysis Before Planting*

30 core soil samples were collected from 0.15 cm depth on the site, mixed thoroughly and the bulked sample was taken to the laboratory, air-dried and sieved with 2 mm sieve and ready routine analysis.

The soil pH(1:1 soil/water and 1:2 soil/0.01M CaCl<sub>2</sub>) were determined using a glass/calomel system (Crockford and Nowell 1956). Organic carbon determination was done using the wet dichromate method (Walkley and Black 1934). The organic C was multiplied by 1.723 to get organic matter (O.M). The exchangeable cations were extracted using 1M NH<sub>4</sub>OAC pH 7 solution and the amount of K, Ca and Na contents were determined on flame photometer using appropriate element filters while Mg content in the extract was read on atomic absorption spectrophotometer (Jackson 1958). The exchangeable acidity (H<sup>+</sup> and Al<sup>3+</sup>) was measured from 0.01M HCl (Mclean 1965). Total nitrogen was determined by mocrak-jedahl

method (Jackson 1964) and the soil available phosphorus was extracted by Bray P1 extractant with Murphy Riley blue coloration (Murphy and Riley 1962) and the concentration measured on spectronic 20 at 882  $\mu\text{m}$ .

#### *Nursery Experiment*

The site was cleared and overhead shade was built for the nursery to prevent sun scorching. 10 kg of the sieved top soil were placed into each polybag measuring 30 x 11 cm. Twelve organic residue treatments viz: cocoahusk, rice bran, wood ash, oil palm bunch ash, cocoa pod husk + duck manure, wood ash + duck manure, oil palm bunch ash + duck manure, cocoa pod husk + turkey manure, rice bran + turkey manure, wood ash + turkey manure and oil palm bunch ash + turkey manure, a nursery recommended chemical fertilizer NPK 15-15-15 applied at 2 g per bag (400 kg/ha) and a control (no fertilizer no manure) were prepared.

The residues were applied at a ratio of 30 g (6t/ha) per bag for the ordinary forms of rice bran, wood ash, oil palm bunch ash and cocoa pod husk while their combination with turkey and duck manure were applied at a ratio of %0:50% by weight (15 g each).

The treatments were incorporated into the soil using handtrowel and were allowed to decompose for two weeks before cocoa seeds were sowed. Each treatment had six polybags each in a set totalling (14 x 6) 84 polybags including the NPK 15-15-15 treatment and control (no fertilization). They were arranged in completely randomized design and replicated four times (84 x 4). The total number of polybags for the treatments and their replication four times totalled 336 polybags.

The seeds germinated 14 days after sowing and the growth parameters such as plant height (cm), leaf area ( $\text{cm}^2$ ), stem girth (cm) and number of leaves were recorded weekly commencing at the 3<sup>rd</sup> week to the 14<sup>th</sup> week after sowing using ruler, vernier calibre and visula counts respectively. At harvest, 20 weeks after sowing, the cocoa seedlings were uprooted carefully for the determination of tap root length and shoot weight.

Weeds in the polybags were regularly controlled. Termite control using Basudin at two weeks interval was carried out and the cocoa seedlings were watered daily.

#### *Chemical Analysis of the Cocoa Seedling Leaves*

Leaf samples were taken from the middle and upper parts of the cocoa seedlings at the 15<sup>th</sup> week after sowing with scatour for each organic treatment, parked into labelled envelopes, oven-dried at 70°C. The dried leaves were weighed into small crucibles and dry-ashed for 6 hours in a muffle furnace at 450°C.

The nutrients in the ashed leaves were extracted with water. % N was determined by micro-kjedahl method (Jackson 1964). The %P was determined by using vanado-molybade yellow coloration and the content was read on spectronic 20 at 442  $\mu\text{m}$ . The % K and Ca were read on the flame photometer using appropriate element filters while the % Mg was determined on atomic absorption spectrophotometry (Jackson 1958).

#### *Soil Analysis After Planting*

Soil samples were taken from each polybag treated with different organic residue treatments using handtrowel at 20 weeks after sowing. The soils were air dried, sieved with 2 mm sieve for routine analysis of total N, available P, exchangeable K, Ca, Mg and Na contents, soil pH and organic matter as described earlier under soil analysis before planting.

#### *Statistical Analysis*

The data collected from the treatment effects of the organic residues on the growth parameters such as height, leaf area, stem girth, leaf population, root length and shoot weight, leaf and soil N, P, K, Ca, Mg soil pH and organic matter were analysed using ANOVA F-test and their means were separated and compared along the treatment effects using Duncan Multiple Range at 5% level.

## RESULTS

#### *Soil Analysis Before Planting*

The physical and chemical properties of the soils used for growing the cocoa seedlings are presented in Table 1. Using the established soil levels in South-West Nigeria for cocoa seedlings, the soils are low in organic matter if compared with the critical level of 3% O.M (Agboola and Corey 1973). The total nitrogen is less 0.13% considered as optimum for cocoa production (Obatolu 1989).

TABLE 1  
Chemical analysis of the soil before the  
experiment parameters

Parameters	
1. Soil pH (1:1 soil/water)	5.50
2. Soil pH (2:1 CaCl <sub>2</sub> )	5.35
3. Organic C(%)	0.24
4. Nitrogen (%)	0.05
5. Phosphorus (mg/kg)	4.43
6. Potassium (cmole/kg)	0.09
7. Calcium (cmole/kg)	0.12
8. Magnesium (cmole/kg)	0.15
9. N+ (cmole/kg)	0.08
10. C.E.C (cmole/kg)	0.44

The low values of soil K, Ca, Mg, Na, P, Total N, and O.M were indications of soils with poor fertility status and cocoa seedling growth on the soil would respond favourably to the application of the organic residues. The soils were sandy loam in texture, skeletal, kaolinitic, isohyportheme oxic paluustalf (Alfisol) or Ferric Luvisol (FAO) or Akure series.

#### *Chemical Composition of the Agricultural Crop Residues*

Table 2 shows the chemical properties of the agricultural crop residues used in the experiment. The duck manure had lower content of N, P, K, Ca and Mg compared to turkey manure. The oil palm bunch had lower content of N and P than that of wood ash. However, the K, Ca and Mg contents were higher in oil palm bunch ash than in the wood ash.

TABLE 2  
Nutrients contents (%) of the agricultural wastes  
used for the experiment

Agricultural wastes	N	P	Ca	Mg	K
1. Cocoa pod husk	1.83	2.37	1.19	0.58	0.41
2. Rice bran	0.076	0.002	0.036	0.012	0.041
3. Wood ash	1.54	0.80	0.12	0.93	0.25
4. Oil palm bunch ash	0.15	0.32	0.19	0.75	0.45
5. Duck manure	1.52	2.59	0.77	0.29	0.75
6. Turkey manure	2.10	5.10	0.21	0.60	0.53

The cocoa pod husk had the highest available contents of P, K, Ca and Mg while the nutrient composition (P, K, Ca and Mg) of wood ash was slightly lower than similar nutrient content in oil palm bunch ash.

#### *Effect of Agricultural Crop Wastes on Wastes on Growth of Cocoa Seedlings*

Table 3 shows the data on plant height, leaf area, stem girth, leaf number, tap root length and shoot weight of cocoa seedlings in different agricultural crop wastes treatments.

The oil palm bunch ash + turkey manure treatment increased the plant height significantly ( $p < 0.05$ ) when compared to the oil palm bunch alone and control treatments. The wood ash, oil palm bunch ash, cocoa pod husk, rice bran applied alone or combined with the turkey and duck manure treatments increased the plant height of cocoa seedlings when compared to NPK treatment. The cocoa seedlings in NPK treatments did not germinate early.

Amongst the sole forms of agricultural waste treatments, the wood ash treatment had the highest plant height increment compared to cocoa pod husk, rice bran and oil palm bunch ash.

The agricultural wastes amended with turkey and duck manures increased the leaf area of cocoa seedlings compared to the wastes applied alone. The wood ash treatment increased the leaf area most compared to rice bran and cocoa pod husk treatments.

The oil palm bunch ash + turkey manure treatments increased the stem girth, leaf number, tap root length and shoot weight significantly ( $p < 0.05$ ) compared to wood ash + duck manure, rice bran + turkey manure and oil palm bunch ash + duck manure treatments.

The unamended wood ash and oil palm bunch ash treatments increased the stem girth, leaf number, tap root length and shoot weight when compared to the unamended rice bran and cocoa pod husk.

#### *Leaf Chemical Composition*

Table 4 presents the leaf chemical composition of cocoa seedlings under the different agro-wastes used. The amendment of oil palm bunch ash with turkey manure treatment significantly ( $p < 0.05$ ) increased N, P, K, Ca, Mg and Na contents in cocoa leaf compared to other treatments. The cocoa leaf nutrient contents in

TABLE 3  
The mean plant height, leaf area, stem girth and leaf number, of cocoa seedlings under different agricultural crop wastes used

Treatments (cm)	Plant height (cm <sup>2</sup> )	Leaf area (cm)	Stem girth	Leaf Number Weight (g) At harvest	Fresh Shoot length (cm) at harvest	Tap root
1. Control	4.20a	12.30a	0.53a	3.06a	20.00a	3.00a
2. NPK 15-15-15	8.30b	21.42b	0.98b	5.50ef	60.00b	10.00b
3. Cocoa pod husk	12.80e	35.40e	1.26de	5.20e	100.00d	12.20d
4. Cocoa pod husk + duck manure	16.50h	54.16g	1.60l	5.72fg	138.00g	15.10f
5. Cocoa pod husk + turkey manure	16.75hi	63.10i	1.68ij	7.0lh	163.00i	20.10h
6. Rice bran	9.45c	23.53c	1.10c	4.20b	85.00c	11.20c
7. Rice bran + turkey manure	15.53g	54.53gh	1.54h	6.30h	123.00f	14.00e
8. Rice bran + duck manure	12.10d	31.60e	1.12c	4.80c	86.00c	11.30c
9. Wood ash	13.10e	38.36f	1.32f	5.60d	113.00e	13.80e
10. Wood ash + duck manure	16.08gh	63.40i	1.70j	6.99h	153.00h	17.00g
11. Wood ash + turkey manure	18.80l	68.30j	1.077k	8.0j	220.00jk	25.00l
12. Oil palm bunch ash	12.30d	31.08d	1.20d	5.00cd	102.0d	12.10l
13. Oil palm bunch ash + duck manure	16.66h	71.10k	1.86l	7.50j	225.00jq	25.00j
14. Oil palm bunch ash + turkey manure	19.40j	77.10l	2.21lm	9.00l	250.0m	27.00k

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

the unamended and amended organic treatments were higher than that of chemical fertilizer and the control treatments.

*Soil Chemical Analysis at the End of Experiment*

Table 5 shows the soil pH, O.M, N, P, K, Ca and Mg contents of soil at the end of the experiment.

The oil palm bunch ash + turkey treatments increased the soil pH, O.M, N, P, K, Ca and Mg contents compared to the unamended wastes and the control treatments. The sole forms of the agricultural waste treatments increased the soil pH, O.M, N, P, K, Ca and Mg contents compared to the control treatments.

TABLE 4  
The % leaf chemical composition of cocoa seedlings under different agricultural treatments

Treatments	N	P	K	Ca	Mg
1. Control (no fertilizer)	0.04a	0.16a	0.08a	0.02a	0.02a
2. NPK 15-15-15	2.40i	2.75m	0.56b	0.03a	0.04ab
3. Rice bran	0.32b	0.24ab	0.58b	0.24b	0.14bc
4. Cocoa pod husk	0.45c	0.35c	0.93c	0.45c	0.26
5. Wood ash	0.73d	0.66d	1.26d	0.63d	0.44e
6. Rice bran + duck manure	0.92ef	0.73de	1.44e	0.67de	0.53f
7. Wood ash + duck manure	1.42i	1.63j	2.30k	1.14gh	0.73hi
8. Cocoa pod husk + duck manure	1.72kl	2.30k	3.20l	2.16l	1.10l
9. Rice bran + turkey manure	1010g	1017gh	1065g	0.93f	0.66gh
10. Cocoa pod husk + turkey manure	1.26h	1.45l	1077gh	1020hi	0.82j
11. Wood ash + turkey manure	1.58j	1.44i	1.93ij	1.53jk	0.84j
12. Oil palm bunch ash manure	0.85de	0.88f	1.48ef	0.99fg	0.58g
13. Oil palm bunch ash + duck manure	1.62jk	1.06g	1.86i	1.40j	0.92jk
14. Oil palm bunch ash + turkey manure	2.20m	2.50l	3.70m	2.55m	1.33m

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 5  
The soil chemical composition of cocoa seedlings after transplanting under different agricultural crop waste treatments

Treatments	%	mg/kg	K	cmol/kg		PH	O.M
	N	P		Ca	Mg		
1. Control	0.03a	3.20a	0.06a	0.03a	0.02a	5.20a	0.24a
2. NPK 15-15-15	0.31h	36.20m	0.63d	0.08b	0.04ab	5.10a	0.26a
3. Rice bran	0.12b	11.30b	0.23b	0.26c	0.18c	6.40b	0.92b
4. Cocoa pod husk	0.18c	14.10c	0.44c	0.34d	0.22cd	6.70d	0.98bc
5. Wood ash	0.25e	17.20d	0.96e	0.84e	0.45e	6.90f	1.56d
6. Rice bran + duck manure	0.19c	19.10e	0.95e	0.86e	0.47ef	6.60c	1.80e
7. Cocoa pod husk + duck manure	0.28fg	22.30f	1.10g	0.92fg	0.50fg	6.80e	1.92f
8. Wood ash + duck manure	0.30h	24.50g	1.30ij	0.96gh	0.52gh	6.90f	1.99fg
9. Oil Palm Bunch Ash + duck manure	0.27ef	26.40gh	1.26hi	1.32l	0.66k	6.50e	2.46jk
10. Rice bran + turkey manure	0.21cd	27.20hi	0.99ef	0.88ef	0.56i	6.90f	2.10h
11. Cocoa pod husk + turkey manure	0.26e	21.80ij	1.40k	1.20ij	0.51fg	7.00g	2.30l
12. Oil Palm bunch ash + turkey manure	0.34i	34.10l	1.72m	1.40m	0.87m	7.30h	2.58m
13. Wood ash + turkey manure	0.20cd	29.70k	1.53l	1.22jk	0.71l	6.90f	2.51l
14. Oil palm bunch ash	0.23e	22.00f	1.20h	1.61i	0.62j	6.80e	2.40j

However, N, P and K contents in chemical fertilizer treated soil increased over the unamended and amended residues but were lower in the soil pH, O.M, Ca and Mg.

### DISCUSSION

The soils normally used for growing cocoa seedlings were generally low in pH, O.M, N, P, K, Ca and Mg and these could be responsible for the poor growth of cocoa seedlings as reflected by the control treatment. The observation supported that of Agboola (1982c) who had reported poor growth responses of cocoa seedlings in soils not fertilized. It was expected that the application of rice bran, wood ash, oil palm bunch ash and cocoa pod husk alone or in combination with turkey and duck manures to the soil would increase the growth responses of cocoa seedlings.

The increase in the plant height, leaf area, stem girth, tap root length and shoot weight of cocoa seedlings grown with the sole and amended agricultural wastes could be due to their rich chemical composition. The observation agreed with Omoti *et al.* (1990) and Obatolu (1999) who reported that oil palm bunch ash, *Chromelina adoration* and cowdung applied at 15t/ha increased the plant height, leaf area and shoot growth of cocoa seedlings.

The nutrient contents on the leaf of cocoa seedlings under the control treatment were below the critical levels of 0.25% P, 1.19% K, 0.8% Ca and 0.7% Mg as reported by Jones and Eck (1973). Thus, the leaves of cocoa seedling were showing deficiency symptoms of P (purple colouration), K (burnt leaf margin), Ca (stunted root growth) and N (yellow colouration).

The application of sole and amended forms of cocoa pod husk, rice bran, oil palm bunch ash and wood ash increased the leaf N, P, K, Ca and Mg contents of cocoa seedlings over the control treatment and this could be attributed to their chemical composition (Table 2). This finding agreed with that of Adv-Dapph *et al.* (1994) and Folorunso (1999) who reported that cocoa pod husk, poultry manure and oil palm bunch ash were good sources of N, P, K, Ca, Mg to the soils for uptake of coffee and Okra crops.

However, the increase in leaf and soil chemical composition and growth performances of cocoa seedlings in the organic residues amended with turkey and duck manures

compared to their sole forms could be attributed possibly to enhancement of their degradation rate by the manure and lower C/N ratio. Since turkey and duck manures are richer in N, P, K, Ca and Mg nutrient content than the plant residues, they are expected to improve soil nutrient availability and enhanced soil fertility.

This observation agreed with that of Obatolu (1999) who reported the nutrients' superiority of *Chromelina adoration* amended with cowdung applied at 15t/ha for growing cocoa seedlings in the nursery compared to either *Chromelina adoration* of cowdung applied alone.

The N, P, K, Ca and Mg nutrients in this organic residue treatment were very important for the growth of cocoa seedlings. For instance, nitrogen is known to be mainly responsible for plant shoot and root growth (Ojeniyi 1984). Shortage of P is associated with reduction in plant growth and K is essential for carbohydrate formation, synthesis of protein and promotion of meristematic tissue (Tisdale and Nelson 1966). The Ca and Mg nutrients encouraged root growth and chlorophyll formation in cocoa seedlings (Ahenkorah *et al.* 1981 and Oladokun 1986).

The better effect of oil palm bunch ash, cocoa pod husk and wood ash on the growth, leaf and soil chemical composition of cocoa seedlings compared to rice bran is consistent with the fact that their soils had higher values of soil pH, O.M, K, Ca and Mg nutrients than that of the latter. The observation agreed with Folorunso (1999) who reported that the rice bran had relatively low C, N, Ca, Mg and Zn contents and a high C/N ratio of 1:23 which would make it more resistant to degradation and their nutrients made more slowly available compared to wood ash, cocoa husk and oil palm seedlings.

The fact that wood ash, oil palm bunch ash and cocoa husk increased the soil pH is consistent with previous findings that ash contains mainly K, Ca and Mg (Ojeniyi 1995) and that cocoa husk is a major source of K (Adv-Dappah *et al.* 1994). The increased soil pH by these residues has confirmed that they were soil ameliorant and Froth (1984) has emphasised the importance of wood ash, oil palm bunch ash and cocoa pod husk with regards to increased availability of cations such as K, Ca and Mg in the soil. The inferior performance of rice bran in improving the soil



pH could be due to its high C:N ratio and consequent immobilization of soil nutrients, especially the cations (Folorunso 1999).

The NPK fertilizer also reduced the soil pH of cocoa seedlings and this might be as a result of  $\text{NH}_4^+$  sorption on the soil surface. The continuous use of 400 kg/ha NPK 15-15-15 (2 g/10 kg soil) was the blanket fertilizer recommendation used for cocoa seedlings both in the nursery and field in Nigeria. The above statement was corroborated by Barber (1962) who reported that large applications of NPK fertilizer continuously might influence the cation concentration in the soil solution and on the exchange phase.

The low soil pH and reduction in organic matter on soils fertilized with the chemical fertilizer adversely affected the Ca and Mg contents of the soils. The observation could be adduced to the high soil P and K which could negatively influence the Ca and Mg availability because of high K/Ca, P/Mg and K/Mg ratio. The implication is that high soil K will result in nutrient imbalance and hidden toxicity for crops (Bear 1950) and could be responsible for the delay in germination and the subsequent poor growth of cocoa seedlings in the experiment.

Therefore, the use of the sole and amended forms of wood ash, oil palm bunch ash, cocoa pod husk and rice bran in the improvement of soil fertility for cocoa seedlings is consistent with the view of Swift and Anderson (1992) who reported that one important mechanism to improve nutrient recycling is through the use of applied organic inputs and retention of crop residues. Yet in many tropical cropping systems, little or no agricultural residues are returned to the soils leading to decline in soil O.M.

### CONCLUSION

Agricultural wastes such as rice bran, cocoa pod husk, oil palm bunch ash and wood ash are effective sources of nutrients because their addition to the soil have enhanced the leaf and soil N, P, K, Ca, Mg, soil pH and O.M, plant height, leaf area, stem girth, root growth and shoot weight of cocoa seedlings.

Rice bran was the least effective while the amended residues with turkey and duck manures improved their effects on these above-mentioned parameters for cocoa seedlings.

It is therefore recommended that agricultural residues such as wood ash, spent grain, cocoa husk pod and oil palm bunch ash and their amendment with turkey and duck manures at 30 g per 10 kg soil (6t/ha) are very useful as fertilizer materials for improving the nutrient availability and ensuring sustainable cultivation of cocoa seedlings on lowly fertile soil in humid tropics.

This recommendation corroborates with the fact that inorganic fertilizers are scarce and expensive for the resource poor farmers who are the growers of cocoa seedlings in most developing countries.

### REFERENCES

- ADV-DAPPAH, H.K, J. COBBINA and E.O. ASARE. 1994. Effect of cocoa pod ash on the growth of maize. *Journal of Agric. Science Cambridge* **132**: 31-33.
- AGBOOLA A.A. 1974. Organic materials as fertilization. *F.A.O. Bull* **27**: 147-152. Rome, Italy.
- AGBOOLA A.A. 1982c. Organic manuring and green manuring in tropical agricultural system. In *Proceedings of 12<sup>th</sup> International Congress of Soil Science*, p. 198-212, 8-16 Feb, New Delhi, India.
- AGBOOLA A.A. and R.B. COREY. 1973. Soil testing NPK for maize in the soil derived from metamorphic and igneous rocks of Western State of Nigeria. *Journal of West African Science Association* **17(2)**: 93-100.
- ARE L.A. 1967. Attempts to improve the performance of budded cacao materials in the green house: Effect of rootstock, age, and time of budding. In *Proc. 2<sup>nd</sup> International Cacao Research Conference*, Bahia, Brazil.
- AHENKORAH Y, B.J. HALM and R.S. AMONDO. 1981. Cocoa pod husk as source of potash fertilizer. *Turtalba* **31(4)**: 287-292.
- BARBER S.A. 1962. Exchange equilibria, selectivity and effective diffusion coefficient of K in soils. *Soil Science Soc. of Amer. J.* **43**: 39.
- BEAR F.E. 1950. Cation-anion relationship in plants and their bearing on crop quality. *Agronomy Journal* **42**: 176-178.
- CROCKFORD, L. and R. NOWELL. 1956. *Laboratory Manual of Physical Chemistry. Experiments 31 and 32*, p. 558-559. New York: John Wiley and Sons.

- FOLORUNSO, O.O. 1999. Use of plant residues for improving soil fertility and the yield of Okra *Abelmoschus esculentum* L and Amaranths *Amaranthus Viridis* L. Ph.D Thesis, Federal University of Technology, Akure.
- FROTH, H.P. 1984. *Fundamental of Soil Science*. 7<sup>th</sup> edition. p. 214-245. Published by Macmillan Press Ltd.
- FOLORUNSO, O.O., A.A. AGBOOLA and G.O. ADEOYE. 1995. Use of fractional recovery model to calculate potassium needs of some soil series in South Western Nigeria. *Journal of Technical Education*, NBTE 1(2): 55-67.
- GILLS and DUFFUS. 1986. Cocoa market report No. 322, March 1986.
- JACKSON, M.L. 1988. *Soil Chemical Analysis*. p. 57-67. Englewood Cliffs, N.J: Prentice Hall.
- JACKSON, M.L. 1964. *Soil Chemical Analysis*. p. 86-92. Englewood Cliffs, N.J: Prentice Hall Inc.
- JONE, B.J. and H.V. ECK. 1973. Plant analysis an aid as in fertilizing corn and grain sorghum. In *Soil Testing and Plant Analysis Revised* ed. L.M. Walsh and J.D. Beaton. *Soil Sci. Soc. Amer*: 349-364. Madison Wisconsin, U.S.
- MCLEAN E.O. 1965. *Aluminium. Methods of Soils Analysis Part 2* ed. M.C.A. Black. p. 927-932. Agronomy 9, Amer Soc. Agron. Madison Wisconsin, U.S.A.
- MURPHY, J. and J.P. RILEY. 1962. A modified single solution method for determination of phosphate in natural waters. *Analytica Glumi-Acta* 27: 31-36.
- OBATOLU L.R. 1983. Cocoa/Arable crop inter-cropping. Ph.D Thesis, University of Ibadan, Ibadan, p. 50-60.
- OLADOKUN M.A.O. 1986. Use of cocoa pod husk as fertilizer for maize production. *Nigerian Journal of Agronomy* 1(3): 103-109.
- OBATOLU L.R. 1999. The growth of cocoa seedlings in the nursery using Chromelina odoration and cowdung. In *Proc. of 26th Annual Conference of Soil Science Society of Nigeria*, Nov 17-22, Bening, Nigeria.
- OJENIYI S.O. 1984. Compound chemical fertilizer and food crop production. Effects of NPK 15-15-15 fertilizer on pepper, cowpea and maize. *Nigeria Journal of Applied Science* 2: 91-95.
- OJENIYI S.O. 1995. That our soil may not die. In *10th Inaugural Lecture of Federal University of Technology*, p. 3, March 23, Akure.
- OMOTI U., L.P. OBATOLU and J.A. FAGBENRO. 1990. Complimentary use of organic and inorganic fertilizers for tree and forest crop production in Nigeria. In *Proc. of 3<sup>rd</sup> Annual Organic Fertilizer Conference*, p. 163-175, Durbar Hotel, Kaduna, Nigeria.
- TISDALE S.L. and W.L. NELSON. 1966. *Soil Fertility and Fertilizers*. p. 20-26. New York: Macmillan Publishing Ltd.
- WALKEY A. and I.A. BLACK. 1934. An examination of Degtjaroff method for determining soil organic acid filtration method. *Soil Sci.* 37: 29-38.

(Received: 4 September 2000)

(Accepted: 9 October 2001)