Comparative Evaluation of Different Organic Fertilizers on Soil Fertility Improvement, Leaf Mineral Composition and Growth Performance of African Cherry Nut (*Chrysophyllum Albidium* L) Seedlings

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Abstract

The effect of wood ash, poultry manure and pig manure as source of fertilizers on soil fertility improvement, leaf mineral composition and growth performance of African Cherry nut (*Chrysophyllum albidium* L) seedlings was investigated at Akure in the rainforest zone of Nigeria. Three organic fertilizer treatments namely poultry manure, wood ash and pig manure were applied at 40g per 10kg soil filled poly bag (8t/ha) along with a reference treatment 400kg/ha NPK 15-15-15 fertilizer (2g per 10kg), replicated four times and arranged in a completely randomized design (CRD). The results showed that these organic fertilizers increased significantly ($P<0.05$) the growth parameters (plant height, stem girth, leaf area, leaf number, root length and fresh shoot weight), soil and leaf N, P, K, Ca, Mg, Soil pH and organic matter (O.M) compared to the control treatment. Poultry manure treatment had the highest values of plant height, leaf area, stem girth, leaf number, root length and fresh shoot weight (kg) of African cherry nut seedlings compared to wood ash, pig manure, NPK 15-15-15 and control treatments respectively. For-instance, poultry manure treatment increased the plant height, lea area, stem girth, leaf number, root length and fresh shoot weight of African cherry nut seedlings by 13%, 8.4%, 4.3%, 7.8%, 15.7% and 30% respectively compared to wood ash. When compared with NPK 15-15-15 fertilizer, poultry manure treatment also increased the plant height, leaf area, stem girth, leaf number, root length and fresh shoot weight of African cherry nut by 9%, 13%, 7%, 18%, 16.9% and 37% respectively. For leaf chemical composition of African cherry nut seedlings, poultry manure had the highest values of leaf N and P while wood ash also had the highest values of leaf K, Ca and Mg compared to others. When compared with NPK 15-15-15 fertilizer treatment, wood ash treatment increased the leaf K, Ca and Mg by 51.7%, 99.3% and 99.5% respectively. However, NPK fertilizer increased leaf N and P by 50.5% and 26.3% compared to wood ash. For soil chemical composition, poultry manure treatment had the highest values of soil O.M, N, P while wood ash also had the highest values of soil pH, K and Mg compared to others. For-example, poultry manure increased the soil O.M, N and P by 6.6%, 44% and 29% compared to wood ash. When compared to NPK 15-15-15 fertilizer treatment, poultry manure increased soil pH, O.M, N, Ca and Mg by 29%, 85%, 34%, 98% and 97% except soil P and K where NPK fertilizer increased these nutrients. The highest soil K.Ca, K/Mg, P/Mg and P/Ca ratios in the NPK 15-15-15 fertilizer caused imbalance in the supply of P, K, Ca and Mg nutrients to African cherry nut seedlings. From this study, poultry manure applied at 8t/ha (40g/10 kg soil) was the most effective treatment in improving African cherry nut growth parameters, soil and leaf mineral composition. [Journal of American Science 2010;6(8):217-223]. (ISSN: 1545-1003).

Key words: Organic fertilizers, soil fertility improvement, growth performance, leaf mineral composition and African cherry nut seedlings.

1. Introduction

African cherry nut (*Chrysophyllum albidium* L) belongs to the family sapotaceae which is up to 25-30m in height with a mature girth varying between 1.5-2 m and simple elliptic to oblong leaves. It produces fleshy fruits which are popularly taken by the people as refreshment, the juice are gum like and can be fermented for the production of wine and alcohol through distillation. Opeke (2005).

Despite the economic and nutritional importance of African cherry nut to the nations, the trees are going into extinction because of the scarcity of young seedlings to replace the few ageing ones in the field. This replacement is becoming difficult due to the problems of raising the plant in the nursery and continued decline in soil fertility status.

Efforts to increase the soil nutrient status is limited by high cost of purchase and scarcity at the farmers

level. Hossian (2000). Therefore, there is justification for the adoption of low cost and sustainable organic fertilizers to grow African cherry nut.

Except the previous works of Moyin-Jesu and Atoyosoye (2002); Moyin-Jesu (2008); Obatolu (1995) who worked on cocoa, dika nut and coffee seedlings using different organic fertilizers, there is paucity of research information on the use of poultry manure, wood ash and pig manure to grow African cherry nut both in the nursery and field.

The objectives of this research work are:

(i) To determine the effect of different organic fertilizers on the growth of African cherry nut seedlings in the nursery.
(ii) To determine the influence of the organic fertilizers on the leaf mineral composition of African cherry nut and soil chemical composition after the experiment.

2. Materials and Methods

The experiment was carried out at Akure in the rainforest zone of Nigeria in 2008 and was repeated in 2009 to validate the results. The soil is sandy, clay loam, skeletal, kalinitic, isohyperthermic oxic paleustalf (Alfisol). Soil Survey Staff (1999). The annual rainfall is between 1100 and 1500mm while the average temperature is 24^{o}C.

Soil sampling and analysis before planting

Thirty core samples were collected randomly from 0-15cm depth on the site using soil auger, 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/O.O1M $CaCl_2$) solution was determined by 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 total nitrogen was determined by the microkjedahl method (AOAC, 1970) while available soil phosphorus (P) was extracted by the Bray P_1 extractant and measured by the Murphy blue colouration and determined on a spectronic 20 at 882Um (Murphy and Riley, 1962).

Soil K, Ca, Mg and Na were extracted with 1M NH_4OAC pH_7 solutions. The K, Ca and Na contents were determined with flame photometer while Mg was determined with an atomic absorption spectrophotometer (Jackson, 1958).

The soil exchangeable acidity (H^+ and Al^{3+}) were determined using O.O1M HCl extracts and titrated with O.1M NaOH (McLean, 1965) while the micronurients (Mn, Cu, Fe and Zn) were extracted with 0.1M HCl (Ogunwale and Udo, 1978) and read on Perkin Elmer atomic absorption spectrophotometer. The mechanical analysis of the soil for soil texture determination was done by the hydrometer method (Bouycous, 1951).

Source and Preparation of Organic Fertilizers

Wood ash, poultry and pig manure were obtained from the cassava processing unit and livestock unit of Federal College of Agriculture, Akure respectively. The organic materials were processed to allow decomposition for easy release of nutrients.

Wood ash was sieved to remove the pebbles, stones and unburnt shafts while pig and poultry manures were air-dried to allow quick mineralization process.

Chemical Analysis of the Organic Materials

Two grams each of the processed forms of the organic fertilizers were analyzed. The percent nitrogen content was determined by 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 wet oxidation method through chromic acid digestion. Walkley and Black (1934).

Collection of African cherry nut seeds for planting

Ripe fruits of African cherry nut were obtained from the few trees at Federal College of Agriculture, Akure. The fruits were carefully opened to remove the seeds embedded with whitish mucilage, carefully washed in water, air-dried for 10 days, parked inside poly bags, labeled and stored for the planting in the nursery experiment.

Nursery establishment of African cherry nut seedlings

The site was cleared to remove weeds and other debris 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 weighed into a poly bag (30x17cm).

There were three organic fertilizer treatments namely wood ash, poultry manure and pig manure applied at 8 tonnes/hectare each (40g of each treatment per 10kg soil) with four replications and arranged in a completely randomized block design (CRD). A reference treatment with 400kg/ha NPK 15-15-15 fertilizer (2g per 10 kg soil) was used along with a control treatment (no fertilizer, no manure).

The treatments were incorporated into the soil using hand trowel and allowed to decompose for one week before planting African cherry nut seeds to the poly bags. Watering was done immediately and

continued every morning and evening until the rain was steady.

The seeds African cherry nut germinated 28 days after planting. Manual weeding started two weeks after planting and continued at every two weeks interval until 22 weeks after planting. Spraying of karate (Lamba cyhalotrin) at 2ml a.i per 6 litres of water against grasshoppers and army worms was done at 3 weeks interval.

The measurement of growth parameters such as plant height, leaf area, number of leaves and stem, girth started at two weeks after planting and continued weekly until 22 weeks after planting.

Representative leaf samples from the top, middle and lower parts of the germinated seedlings were randomly taken at 23 weeks after planting per each treatment using a secateur, 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 6 hours and the ash was made into solution, filtered and analyzed for N, P, K, Ca and Mg as described earlier.

At 26 weeks after planting in the nursery, the seedlings were ready for final transplanting in the field and at the end of the experiment, soil samples were also collected from each treatment, air-dried, sieved using 2mm sieve and analyzed for N, P, K, Ca, Mg, soil pH and organic matter.

Statistical Analysis

The average data obtained for the growth parameters such as plant height, leaf area, number of leaves and stem girth, soil chemical composition and leaf mineral composition of African cherry nut seedlings in 2008 and 2009 were analyzed using ANOVA F-test while the treatment means were separated using Duncan Multiple Range Test at 5% level. Gomez and Gomez (1984).

3. Results

Soil chemical composition before planting

Table 1: Soil fertility status before planting African Cherry nut

Soil parameters	Values	
Soil pH (H_2O)		5.45
Soil pH O.O1M $CaCl_2$	5.32	
Organic matter (%)		0.56
Nitrogen (%)		0.05
Available P (mg/kg)		6.10
Exchangeable bases		
K^+(mmol/kg)		0.10
Ca^{2+}(mmol/kg)	0.11	
Mg^{2+}(mmol/kg)	0.09	
Al^{3+}(mmol/kg)		1.48
Fe(mg/kg)		8.50
Zn (mg/kg)		3.75
Mn (mg/kg)		1.80
Cu (mg/kg)		2.0
Sand (%)		79.10
Silt (%)	15.20	
Clay (%)		5.70
Soil bulk density (mgm^{-3})	1.60	
% Porosity		41.81

The soil chemical properties before planting are presented in Table1. Based on the established critical levels for soils in South West Nigeria, the soil was acidic with pH 5.45 and low in organic matter compared to the critical level of 3% organic matter (Agboola and Corey 1973).

The total nitrogen (0.05%) is far less than 0.15% which is considered optimal for most crops (Sobulo and Osiname, 1981) while the available P is less than 10mg/kg P critical level (Agboola and Corey 1973).

The exchangeable K (0.10), Ca (0.11) and Mg (0.09mmol/kg) were lower than 0.20cmol/kg critical levels considered as adequate for crops (Folorunso *et al*, 2000). The soil textural class is sandy loam and it is classified as Akure soil series which is equivalent to Alfisol (*Isohyperthermic oxic paleustalf*). Soil Survey Staff (1999).

Chemical composition of the organic fertilizers used

Table 2: Chemical analysis of the organic fertilizers used for the experiment.

Treatments (organic fertilizers)	C	% N	% ratio	C/N mg/kg	P	K %	Ca	Mg	Fe mg/kg	Cu	Zn
Poultry manure		32.10	4.53	7.08	385	0.97	0.32	0.41	37.85	0.15	1.26
Pig manure	30.00	3.72	8.06	312	1.44	0.31	0.40	34.0	0.17	1.3	
Wood ash		18.00	1.53	11.76	86	2.30	0.94	0.85	65.55	0.66	1.83

The chemical analysis of the organic fertilizers materials used for growing African cherry nut seedlings is presented in Table 2. Poultry manure had the highest values of N, P and lower C/N ratio compared to pig manure and wood ash respectively. Wood ash had the highest values of K, Ca and Mg contents compared to the poultry and pit manures.

Effect of organic fertilizers on the growth parameters of African cherry nut seedlings

Table 3: Effect of different organic fertilizers on the growth parameters of African Cherry nut seedlings.

Treatment	Plant height (cm)	Leaf area (cm^2)	Stem girth (cm)	Leaf number	Root length (cm)	Fresh weight (kg)
Poultry manure	35.24e	87.62d	3.69e	14.1d	8.3d	3.0e
Wood ash	30.75b	80.25c	3.53cd	13.0c	7.0b	2.1bc
Pig manure	32.55d	80.65c	3.50c	13.2c	7.6c	2.4d
NPK 15-15-15	32.02c	76.29b	3.42b	11.6b	6.9b	1.9b
Control	27.19a	61.68a	1.82a	7.5a	5.7a	0.9a

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.

There were significant increases ($P<0.05$) in the plant height, stem girth, leaf area, leaf number, root length and fresh weight (kg) under different organic fertilizers compared to the control treatment. (Table 3).

Poultry manure treatment had the highest values of plant height, leaf area, stem girth, leaf number, root length and fresh shoot weight of African cherry nut seedlings compared to wood ash, pig manure, NPK 15-15-15 and control treatments respectively.

For instance, poultry manure treatment increased the plant height, leaf area, stem girth, leaf number, length and fresh shoot weight of African cherry nut seedlings by 13%, 8.4%, 4.3%, 7.8%, 15.7% and 30% respectively compared to wood ash.

When compared with NPK 15-15-15 fertilizer, poultry manure treatment increased the plant height, leaf area, stem girth, leaf number, root length and fresh shoot weight of African cherry nut seedlings by 9%, 13%, 7%, 18%, 16.9% and 37% respectively.

All the treatments had better values of growth parameters of African cherry nut seedlings than that of control treatment.

Effect of organic fertilizers on the leaf chemical composition (%) of African cherry nut seedlings

Table 4: Leaf analysis of African Cherry nut seedlings under different organic fertilizers treatments.

Treatment	N %	P %	K %	Ca (%)	Mg (%)
Poultry manure	1.27d	0.99d	0.65c	0.53d	0.32d
Wood ash	0.89b	0.67c	1.45e	0.73e	0.66e
Pig manure	0.92bc	0.56b	0.59b	0.45c	0.24c
NPK 15-15-15	1.80e	0.91d	0.70d	0.005a	0.003a
Control	0.04a	0.024a	0.03a	0.04b	0.05b

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

There were significant increases ($P<0.05$) in leaf N, P, K, Ca and Mg of African cherry nut seedlings compared to the control treatment. (Table 4).

Among the organic fertilizer treatments, poultry manure had the highest values of leaf N and P while wood ash also had the highest values of leaf K, Ca and Mg contents compared to others.

For example, poultry manure treatment increased leaf N and P of African cherry nut seedlings by 27.5% and 43% compared to pig manure while wood ash treatment increased the leaf K, Ca and Mg by 55%, 27% and 52% respectively compared to the poultry manure treatment.

When compared to NPK 15-15-15 treatment, wood ash treatment increased leaf K, Ca and Mg of African cherry nut seedlings by 51.7%, 99.3% and 99.5% respectively. However, NPK 15-15-15 fertilizer increased leaf N and P by 50.5% and 26.3% compared to wood ash.

Generally, NPK 15-15-15 fertilizer had the highest values of leaf N content compared to poultry manure, wood ash, pig manure and control treatments.

The leaf K/Ca and K/Mg ratios were 140:1 and 223:1 under NPK 15-15-15 fertilizer treatments compared to K/Ca (1:1) and K/Mg (2:1) under the poultry manure treatment.

Effect of organic fertilizers on soil chemical properties after removing African cherry nut seedlings

Table 5: Soil Chemical Analysis after Experiment under different organic fertilizers.

Treatment	Soil pH (H_2O)	O.M %	N %	Available P(mg/kg)	K mmol/kg	Ca mmol/kg	Mg mmol/kg
Poultry manure	6.13c	1.97c	0.32d	24.0d	2.6c	2.0d	1.23c
Wood ash	6.80d	1.84b	0.18b	17.0b	2.72cd	1.97c	1.32d
Pig manure	6.50c	1.90b	0.20c	21.2c	2.38b	1.48b	1.08b
NPK 15-15-15	4.36a	0.30a	0.21c	25.9e	3.55e	0.03a	0.04a
Control	5.35b	0.35a	0.03a	3.66a	0.04a	0.06a	0.07a

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

There were significant increases ($P<0.05$) in soil pH N, P, K, Ca, Mg and O.M compared to the control treatment under different organic fertilizer treatments (Table 5).

Poultry manure treatment had the highest values of soil O.M, %N and P while wood ash also had the highest values of soil pH, K and Mg. For instance, poultry manure treatment increased the soil O.M, N and P by 6.6%, 44% and 29% compared to wood ash.

In-addition, wood ash increased the soil pH, K, Ca and Mg contents by 4.5%, 12.5%, 25% and 18% respectively compared to pig manure treatment.

When compared to NPK 15-15-15 fertilizer treatment, poultry manure increased soil pH, O.M, N, Ca and Mg by 29%, 85%, 34%, 98.5% and 97%. However, NPK 15-15-15 fertilizer increased soil P and K by 7.3% and 26.7% compared to poultry manure.

NPK fertilizer treatment decreased significantly ($P<0.05$) soil pH, O.M, Ca and Mg contents after removing the African cherry nut seedlings compared to the initial soil fertility status.

NPK fertilizer treatment had higher ratios of K/Ca, K/Mg, P/Mg and P/Ca interactions. For-instance, the soil K/Ca, K/Mg, P/Mg and P/Ca interactions were 118:1, 89:1, 647:1 and 863:1 respectively in NPK 15-15-15 fertilizer treatment compared to K/Ca (1:1), K/Mg (2:1), P/Mg (20:1) and P/Ca (12:1) under poultry manure treatment.

4. Discussion

The increase in growth parameters such as plant height, leaf area, stem girth, leaf number, root length and fresh shoot weight of African cherry nut seedlings could be attributed to the nutrient contents of the organic fertilizers used which encouraged better seedlings growth. This observation agreed with Adebayo and Akoun (2000) and Moyin-Jesu (2007) who reported that organic manures supported crop growth performance and increased crop yield.

Poultry manure gave the best performances on the growth, leaf and moderate soil fertility and this could be as a result of its high values of N, P, K and moderate Ca and Mg. This finding also agreed with Babalola *et al* (2000) who reported that poultry manure when used as fertilizer usually stimulated microbial activities and thereby enhanced the release of organic nitrogen and phosphorus in the soil. Soil nitrogen had been reported by Ojeniyi (1984) to aid vegetable growth and yields of crops.

The values reported for soil pH before the experiment was acidic but the application of wood ash increased the soil pH to a near neutral level. This could be due to the fact that wood ash was rich in K, Ca and Mg which created a liming effect in soil and stability of the soil buffering capacity. The observation agreed with the work of Gordon, 1998 and Moyin-Jesu 2009. Soil pH had been reported to influence nutrient availability and uptake by crops (Aduayi, 1980).

The application of NPK 15-15-15 fertilizer at 400kg/ha has led to high soil K/Ca, K/Mg, and P/Ca ratios which made difficult the availability of K, Ca and Mg nutrients to crops. This could be responsible for the lower values of soil Ca, Mg, O.M and pH compared to poultry manure, wood ash and pig manure respectively. Hence, the above observation was further supported by the fact that NPK 15-15-15 fertilizer decreased soil pH from 5.45 to 4.36.

Therefore, Obi and Ofonduru (1997) reported that the continuous use of mineral fertilizers such as NPK, Urea and Ammonium sulphate had led to degradation of soil physical qualities and low soil organic matter level.

The least values recorded for the soil, growth and leaf parameters of African cherry nut seedlings under the control treatment could be attributed to the initial poor soil fertility status and continuous cultivation of the land without replenishing with appropriate fertilizer. This observation agreed with Woomer and Muchena (1993) who reported that continuous productivity of tropical soils is associated with maintenance and improvement of soil physical characteristics which can be further improved by applying organic fertilizers.

5. Conclusion and Recommendation

The application of organic fertilizers such as poultry manure, wood ash and pig manure at 8 t/ha (40g/10kg soil) increased significantly the soil, leaf N,P, K, Ca, Mg, Soil pH and O.M, plant height, stem girth, leaf number, leaf area, root length and fresh shoot weight of African cherry nut seedlings. It is recommended that poultry manure applied at 8t/ha (40g/10kg soil) was the most effective fertilizer material for improving the nutrient availability and ensuring sustainable cultivation of African cherry nut seedlings on a commercial basis.

This recommendation corroborates with the fact that inorganic fertilizers are becoming too expensive to purchase by small scale farmers of African cherry nut. Besides, these organic fertilizers appear to have a strong beneficial secondary effects on the soil properties and could be environmental friendly.

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13/05/2010