Growth Response of *Garcinia kola* Heckel Seedlings to Organic and Organomineral Fertilizers

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ABSTRACT

Growth responses of *Garcinia kola seedlings* to organic manure and organomineral fertilizer at three different levels were examined. Seven treatments were applied namely T1- 2t/ha of *Leucaena leucocephala* compost (LLC), T2- 4t/ha LLC, T3- 6t/ha LLC, T4 - 2t/ha of organomineral fertilizer (OMF), T5- 4t/ha OMF, T6- 6t/ha OMF and T7- control. *Garcinia kola* seedlings of same size were selected and transplanted from germination trays after 6weeks into medium sized polypots filled with 2kg topsoil after 6months from germination tray. The experimental design was a Completely Randomized Design (CRD) with five replicates. The growth parameters assessed include plant height, collar diameter, number of leaves and biomass production for a period of twenty weeks. The results showed that there were significant differences among the growth parameters. *Garcinia kola* seedlings treated with 6t/ha *Leucaena leucocephala* compost and 2t/ha organomineral fertilizer gave highest plant height (22.8±1.24cm) and collar diameter (5.02±0.16mm) respectively. Treatment containing 2t/ha *Leucaena leucocephala* compost gave the highest leaf number (9.2±1.74), wet weight (10.58±0.47g) and dry weight (4.00±0.25g) respectively. Correlations coefficient (r) between the growth parameters and total biomass production showed positive correlation and statistically significant at 5.0%. Organic and organomineral fertilizers with optimum growth in this study are recommended for raising good and healthy *Garcinia kola* seedlings in the nursery for plantation establishment.

Keywords: *Garcinia kola*, organic manure, organomineral fertilizer, growth parameters

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INTRODUCTION

Garcinia kola (Heckel), commonly called "Bitter kola" belongs to the family Guttiferae (Hutchinson and Dalziel, 1954). It is highly valued multi-purpose tree for its fruits, seeds, stems, roots and barks that are used in Western and Central African regions (Hutchinson and Dalziel, 1954). It is a dicotyledonous plant found in moist rainforests and swamps and grows as a medium sized tree up to a height of about 12m high. The bitter kola plant is found in countries across West and Central Africa and it is distributed by man around the towns and villages of countries like; Nigeria, Ghana, Cameroon, Sierra Leone, Togo, Congo Democratic Republic, Angola, Liberia, Gambia among others **(**Hutchinson and Dalziel, 1954). The edible nut is highly valued in these countries (Adesuyi *et al*., 2012).

In Nigeria, it is known by various names such as bitter kola, male kola (English name), orogbo (Yoruba), Aku ilu (Igbo) and Mijin goro (Hausa). It is also known as male kola due to its reported aphrodisiac properties (Adebisi, 2004; Adesuyi *et al*., 2013). *G. kola* seeds are chewed as a mastocatory substance to stimulate the flow of saliva, and widely consumed as snack unlike other kola nuts (*Kola nitida, Kola acuminata*), *G. kola* is thought to have the property of cleaning the digestive system without abdominal problems, even when a lot of the nuts are eaten (Adebisi, 2004)**.** The seed is culturally very important to the Yoruba and Igbo tribes in Nigeria and for many other people living in sub Saharan Africa. For centuries, the nuts have been an important part of traditional ceremonies, marking special events like births, marriages, and conferring chieftaincy titles. A *G. kola* nut tree may be planted when a baby is born with the child becoming its lifelong owner. In proposal of marriage, young men offer *G. kola* nuts to the father of the bride and exchange of *G. kola* nuts is essential in many business dealings as well (Ofusori *et al*., 2008).

The traditional African medicinal uses include treatment of cough, purgative, anti- parasitic, anti- microbial. The seed is used in the treatment of diarrhea, bronchitis, throat infections and liver disorder. The G. kola seeds enjoy a folk reputation in Africa as poison antidote (1). In addition, the plant possesses anti-hepatotoxic antioxidant, hypoglycemia, anti-inflammatory and aphrodisiac properties (Iwu, 2003; Irvine, 1960; Esimone *et al*., 2002,

Faronbi *et al*., 2005)

Garcinia kola seedlings are slow growing at the nusery stage. Seedlings with good vigour at the nusery stages tend to perform better when taken to the field after culling and hardening up. Organic based fertilizer such as organomineral fertilizer improves soil structure, reduces soil erosion, lowers the temperature at the soil surface, and increases soil water holding capacity (Roe et al., 1997). Resource poor farmers are faced with limited resources to purchase mineral fertilizers, resort to use of organic fertilizer. Similarly, the detrimental effects of mineral fertilizers on soils in the long term usage, necessisated the need for testing the effectiveness of organic and organomineral fertilizers to *Garcinia kola* seedlings in this study. Besides they are are readily available, cheap, sustainable and environmentally friendly. Therefore, this study examined the growth responses of *Garcinia kola* seedlings to organic manure and organomineral fertilizer at three different levels in the nursery in order to find the best level to use for plantation establishment of *Garcinia kola* .

MATERIALS AND METHODS

Experimental site

The study was conducted in the greenhouse of the Soils and Tree Nutrition Section, Department of Sustainable Forest Management of Forestry Research Institute of Nigeria (FRIN). FRIN lies within latitude 07^{O}23'N and longitude 03^{O}51'E with the mean total rainfall of 1148.1 mm, falling in approximately 87 days with the minimum temperature of 24.4^{O}C, and maximum temperature of 31.5^{O}C and with high relative humidity of 79.4% (FRIN 2014).

Collection and Analysis of Soil

Top soils (0–15 cm) were randomly collected with soil auger from the aboratum of Forestry Research Institute of Nigeria. The soils were bulked, mixed and sieved with a 2mmmesh to remove gravel and plant roots. The 2 kg polythenebags used for the experiment were filled with the sieved soil.Particle size analysis was carried out using hydrometer method

(Bouyoucos 1962). The pH was determined in water (ratio 1: 1, soil:water). Organic carbon was determined by wet dichromate method (Nelson and Sommers, 1975) and available phosphorus was determined by Bray extraction method (Anderson and Ingram, 1993). Total nitrogen was determined by Kjeldahl method. Exchangeable cations (potassium, calcium, and magnesium) were extracted with ammonium acetate. Potassium was determined by flame photometer method, while calcium and magnesium were determined by atomic absorption spectrophotometer. Copper, zinc, manganese, and iron were also determined by the method used by IITA (1979).

Seed Source, Data Collection and Analysis

Matured fruits of *Garcinia kola* were collected from the mother tree at Uromi, Esan North East Local Government Area (LGA) in Edo State, Nigeria. The seeds were extracted from the fruits, washed and air dried at room temperature for three (3) days in line with the method of Yakubu *et al.*, (2014). Seeds of Garcinia kola of uniform sizes were sown into nursery beds and watered daily. After six weeks, the seedlings of similar heights and vigor were selected and transplanted into medium sized polypots containing 2kg topsoil after 6weeks.The study was carried out with with a Completely Randomized Design (CRD) with five replications. The experiment consisted of T1- 2t/ha of *Leucaena leucocephala* compost (LLC), T2- 4t/ha LLC, T3- 6t/ha LLC, T4- 2t/ha of organomineral fertilizer (OMF) , T5- 4t/ha OMF, T6- 6t/ha OMF and T7: control. Two months after transplanting, data were collected for twenty four weeks on plant height (cm), collar diameter (mm) and number of leaves at monthly intervals. The seedlings were then harvested and data collected on plant wet and dry weight and roots were washed off any soil particles and divided into root and shoot components for each treatment and put in separate envelopes and dried in an oven for 7days set at 60^0C to constant weight. The dried plant materials were removed from the oven and allowed to cool under desiccators and their dry weights determined with an electronic balance. Data obtained were subjected to statistical analysis of variance, means were separated Using Duncan's Multiple Range test (Duncan, 1955) at 5% probability level

RESULTS

The experimental soi was sandy loam in texture and slightly acidic. Medium in organic carbon and Nitrogen. The P_H, Organic carbon, total N, Available P and K values were 6.2, 5.3, 1.17, 4.05 and 0.17% respectively. Most of the nutrients in this soil were low and below the critical level Adeoye and Agboola (1985), this justifies the application of soil amendment in form of organic and organomineral fertilizers to *G. kola* seedlings (Table 1). The organomineral fertilizer used for the experiment contained organic matter 69.96%, organic carbon 29.76%, Total N 3.54% and P 1.68% respectively, while the *Leucaena leucocephala* compost contained N 3.86%, P 0.08% , K 1.29%, Ca 1.09% , Mg 0.41%, K 1.29% , Zn 37.05ppm respectively. The Nitrogen content of the organomineral fertilizer and *Leucaena leucocephala* compost were higher than that of the experimental soil, thus it will improve the soil fertility and the performance of the *G. kola* seedlings in the nursery.

TABLE 1: Soil Physical and Chemical Properties Collected at 0- 15cm Depth

PARAMETERS	VALUE
Soil P^H	6.20
Organic C (%)	5.30
Total N (%)	1.17
Avail P (mg/kg)	4.05
Exchangeable Cations (cmol/kg)	
Ca	1.53
Mg	0.75
Na	0.10
K	0.17
Exchangeable Acidity	0.57
Base Saturation (%)	67.91
CEC	3.22

Available Micronutrient (Mgkg-1)	
Mn	20.59
Fe	9.72
Cu	7.17
Zn	4.41
Physical Analysis (%)	
Sand	74.53
Silt	21.07
Clay	4.40
Textural Class	Sandy Loam

TABLE 2: Nutrient Composition of Chemical Properties of Organo-mineral Fertilizer Grade B (OFB)

PARAMETERS	**VALUE**
P^{H}	6.46
Organic matter	69.96
Organic carbon	29.76
Total N(%)	3.54
P(%)	1.68
PARAMETER(mg/kg)	**VALUE**
Cd	1.36
Cr	11.18
Cu	4.20
Ni	9.3
Pb	19.65
Zn	328.00

Source: Aleshinloye Fertilizer Company, Ibadan, Nigeria.

TABLE 3: Nutrient Composition of *Leucaena Leucocephala* Compost

Parameter (%)	Value
N	3.86
P	0.08
K	1.29
Ca	1.09
Mg	0.41
Zn(ppm)	37.05

TABLE 4: Height (cm) of *Garcinia kola* seedlings at different intervals

TREATMENTS	4WAT	8WAT	12WAT	16WAT	20WAT	24WAT
2t/ha LLC	10.08^{a}	11.20^{a}	12.58^{a}	15.10^{a}	15.76^{a}	17.78^{ab}
4t/ha LLC	9.82^{a}	10.90^{a}	11.97^{a}	12.56^{a}	12.74^{a}	16.40^{ab}
6t/ha LLC	9.98^{a}	11.53^{a}	12.48^{a}	15.30^{a}	16.40^{a}	22.80^{a}
2t/ha OMF	10.02^{a}	11.94^{a}	12.98^{a}	15.04^{a}	16.60^{a}	20.40^{ab}
4t/ha OMF	9.80^{a}	10.55^{a}	10.54^{a}	11.72^{a}	12.50^{a}	15.20^{b}
6t/ha OMF	9.30^{a}	10.94^{a}	11.80^{a}	14.90^{a}	16.06^{a}	19.16^{ab}
Control	10.36^{a}	8.94^{a}	9.13^{a}	10.04^{a}	12.90^{a}	14.01^{b}

Means followed by the same letters within the same column are not significantly different ($p< 0.05$) T1: 2t/ha *Leucaena leucocephala* compost (LLC), T2: 4t/ha LLC, T3: 6t/ha LL, T4: 2t/ha organomineral fertilizer (OMF) T5: 4t/ha OMF T6t/ha OMF and T7: control.

TABLE 5: Collar diameter (mm) of *Garcinia kola* seedlings at different intervals

TREATMENTS	4WAT	8WAT	12WAT	16WAT	20WAT	24WAT
2t/ha LLC	3.26[a]	3.54[a]	3.74[a]	3.66[a]	4.24[a]	4.60[ab]
4t/ha LLC	2.89[a]	3.16[a]	3.97[a]	3.53[a]	4.20[a]	4.51[ab]
6t/ha LLC	2.91[a]	3.56[a]	3.56[a]	3.66[a]	4.28[a]	4.38[ab]
2t/ha OMF	3.19[a]	3.62[a]	3.43[a]	3.69[a]	4.77[a]	5.02[a]
4t/ha OMF	2.68[a]	2.86[a]	3.09[a]	3.26[a]	4.40[a]	4.43[ab]
6t/ha OMF	3.07[a]	3.58[a]	3.65[a]	3.41[a]	4.28[a]	4.50[ab]
Control	2.69[a]	2.94[a]	3.13[a]	2.99[b]	3.04[b]	3.92[b]

Means followed by the same letters within the same column are not significantly different (p< 0.05) T1: 2t/ha *Leucaena leucocephala* compost (LLC), T2: 4t/ha LLC, T3: 6t/ha LL, T4: 2t/ha organomineral fertilizer (OMF) T5: 4t/ha OMF T6t/ha OMF and T7: control.

TABLE 6: Number of leaves of *Garcinia kola* seedlings at different intervals

TREATMENTS	4WAT	8WAT	12WAT	16WAT	20WAT	24WAT
2t/ha LLC	3.8[a]	4.0[a]	5.2[a]	5.8[a]	7.6[a]	9.2[a]
4t/ha LLC	3.8[a]	4.4[a]	4.2[a]	5.0[a]	6.2[ab]	6.8[ab]
6t/ha LLC	4.6[a]	4.6[a]	5.2[a]	5.8[a]	6.2[ab]	8.0[ab]
2t/haOMF	3.8[a]	4.6[a]	5.4[a]	5.4[a]	6.4[ab]	7.4[ab]
4t/haOMF	3.8[a]	4.0[a]	4.6[a]	4.6[a]	5.0[b]	6.0[b]
6t/haOMF	4.0[a]	5.2[a]	5.4[a]	5.8[a]	6.2[ab]	6.8[ab]
Control	3.6[a]	4.2[a]	5.6[a]	6.0[a]	6.8[ab]	7.6[ab]

Means followed by the same letters within the same column are not significantly different (p< 0.05) T1: 2t/ha *Leucaena leucocephala* compost (LLC), T2: 4t/ha LLC, T3: 6t/ha LL, T4: 2t/ha organomineral fertilizer (OMF) T5: 4t/ha OMF T6t/ha OMF and T7: control.

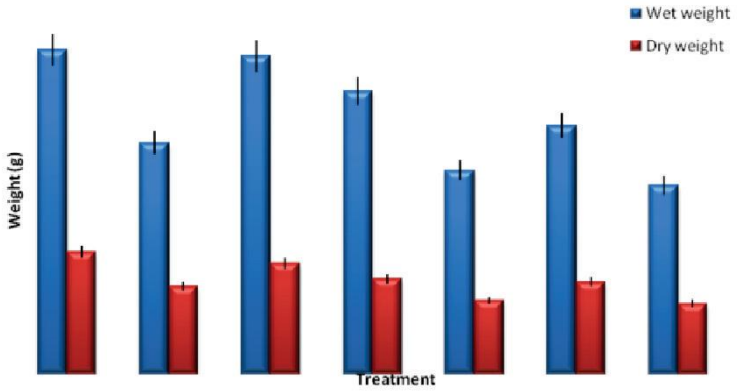

Figure 1: Biomass Weights of *Garcinia kola* Heckel

TABLE 7: Correlations coefficient (r) between the growth parameters and total biomass of Garcinia kola

Parameter	r value
Plant height vs Stem diameter	0.712**
Plant height vs number of leaves	0.332*
Plant height vs Leaf area	0.527**
Plant height vs Dry weight	0.540**
Stem diameter vs Wet weight	0.533**
Stem diameter vs Number of leaves	0.332*
Stem diameter vs Leaf area	0.689**
Stem diameter vs Dry weight	0.621**
Stem Diameter vs Weight weight	0.615**
Number of leaves vs Leaf Area	0.287*
Number of leaves vs Dry weight	0.261*
Number of leaves vs Wet weight	0.232*
Leaf Area vs Dry weight	0.267*
Leaf Area vs Wet weight	0.407**
Dry weight Vs Wet weight	0.770**

****. Correlation is significant at the 0.01 level (2-tailed).**
***. Correlation is significant at the 0.05 level (2-tailed).**

Plant Height

The plant heights of *Garcinia kola* seedlings were not significantly different between treatments at 4weeks After Transplanting Planting (WAT) months respectively. At 8, 12 and 16WAT, control recorded the least mean plant heights of 8.94 cm, 9.13 cm and 10.04 cm respectively; there were significant difference between control and other treatments. At 24 WAT, there were no significant differences among treatments. However application of 2t/ha of Organomineral fertilizer (OMF) recorded highest mean plant height of 16.60cm. At 24 WAT, 6t/ha LLC recorded the highest mean plant height of 22.8 cm while the control recorded the least plant height of 14.01cm (Table 4).

Collar Diameter

The collar diameter did not show significant differences among treatments at 4, 8 and 12 WAT except at 16, 20 and 24 WAT. At 20 WAT, seedlings grown with 2 t/ha OMF recorded the highest mean stem diameter of 4.77 mm, which was significantly different from the control. The control recorded the least value of 3.04 mm. At 24 WAT the range of the collar diameter was between 3.92 - 5.02 mm. Treatment containing 2 t/ha OMF recorded significantly higher collar diameter than other treatments. Control had the lowest stem diameter (3.92 mm) at the end of the experiment (Table 5).

Total Number of Leaves

The total number of leaves followed similar trend with the collar diameter. No significant differences were recorded from 4 WAT to 16 WAT. At 20 WAT treatment containing 4 t/ha Organomineral fertilizer (OMF) recorded the least value of (5.0) mean total number of leaves. At 24 WAT the leaf number was in the range (6.0 to 9.20). Treatment with 2 t/ha LLC had the maximum number of leaves (9.20) while treatment of 4t/ha OMF recorded the least value of 6.0 (Table 6).

Total Biomass

Total biomass assessment at the end of the experiment, revealed highest wet weight and dry weight (10.58 g, 4.00 g) that was recorded by 2 t/ha OMF, and followed in this order 2t/ha LLC 6 t/ha LLC > 2 t/ha OMF > 6t/ha OMF > 4t/ha LLC > 4t/ha OMF > Control(Figure 1).

Correlation Analysis:

At 24 weeks after transplanting, correlation coefficients of plant diameter and height (0.577), diameter and number of leaves (0.551), height and number of leaves (0.441) were positive and statistically significant at 1.0 %. Plant diameter increases together with height and number of leaves. Similarly plant height also increases with number of leaves. Plant height increases with wet weight (0.342) and dry weight (0.394) at 5.0 % significant level. Wet and dry weights are positively and significantly correlated (0.961) at 1.0 % significant level, that is they increase at the same rate. (Table 7)

DISCUSSION

Nursery seedling production is the most common practice for raising planting stock and the use of plants produced from the nursery is generally the most efficient and effective way of establishing a forestry plantation in the forest (Evans and Turndull, 2004). The result on analysis of experimental soil reveals that they contain low levels of nitrogen, phosphorus, and organic carbon which are in agreement with the findings earlier obtained (Adeoye and Agboola, 1985; Aduayi *et al*., 2002). They reported that most of Nigerian soil is deficient in nitrogen, phosphorus, and potassium including even organic matter. The effect of compost and other organic amendment on the growth of *Garcinia kola* may be as a result of the interaction between the nutrient present and growth of *Garcinia* seedlings, as organic manure has been found to contain auxins, gibberellins, and cytokinis (Miezah, et al., 2008; Stoffella *et al*., 1997). Organic base fertilizer such as organomineral fertilizer improves soil structure, reduces erosion, lowers the temperature at the soil surface, and increases soil water holding capacity (Roe *et al*., 1997). Similar results were observed by previous workers on application of organic

and organnomineral fertilizer on tree crops. Dania *et al*., (2014), examined the comparative effects of NPK, poultry manure, and organnomineral fertilizer on the growth of *Moringa oleifera* seedlings and their nutrient concentration were investigated after the experiment. It was reported that organic base fertilizer (OMF) improved the nutrient content (calcium, potassium, and sodium of moringa. Tambe Bechem *et al*., (2013), concluded in their findings that nitrogen and phosphorus fertilizers obviously had beneficial effects on growth parameters (heights, leaf numbers, collar diameter, leaf area and total biomass production) of *Cederella odorata, Terminalia. superba and E. angolensis* seedlings in nursery. It was also observed that generally, all the fertilizer combinations influenced the growth of seedlings in the nursery as the values were better than those observed with the control. Shodeke *et al*., 2012; observed that organic based treatments appeared to produce better growth. In his study, composted leaf litter of *Gliricidia sepium* and *Tithonia diversifolia* applied at 10t/ha mixture combination (10t/ha GS + 10t/ha TD) can be applied as organic amendment to improve the growth performance and early development of *Nauclea diderrichii* seedlings instead of mineral fertilizers – NPK 15:15:15. Moyin-Jesu and Adeofun (2008), observed in their work that 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. Thus, they recommended that amended oil palm bunch ash and 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. Gbadamosi (2006) showed that seedlings of *Enantia chlorantha* , a medicinal plant, supplied with 0.3g and 0.4g compost recorded the best growth performance in terms of stem diameter, number of leaves and leaf area, while 0.4g compost had the highest value for root and leaf dry weights.

CONCLUSION

In this work, the application of *Leucaena leucocephala* compost (LLC) and Organomineral fertilizer (OMF) at different rates improved the soil fertility and the performance of the *G. kola* seedlings in the nursery at 24 weeks after transplanting. Increased growth of *Garcinia kola* seedlings was enhanced mostly by 2 t/ha organomineral fertilizer (OMF) and 6t/ha of *Leucaena leucocephala(*LLC*)* compost. The vegetative growth of *Garcina kola* seedlings were significantly influenced by application of 6t/ha Leucaena leucocephala compost (22.8±1.24cm). However 2t/ha organomineral fertilizer (5.02±0.16mm) recorded the highest plant height and collar diameter respectively. 2t/ha *Leucaena leucocephala* compost (9.2±1.74) gave the highest leaf number. Organic and organomineral fertilizers with optimum growth in this study are recommended for raising good and healthy *Garcinia kola* seedlings in the nursery for plantation establishment.

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