Soil amendments for enhanced field establishment and yield of *Gnetum africanum* (Okazi) plantlets in Owerri, Southeastern Nigeria

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Abstract

Establishment of *Gnetum africanum* plantlets in the low fertility tropical Ultisols is difficult. An experiment was carried out on the effects of five soil amendments – kitchen ash (2400 kg/ha), poultry manure (2400 kg/ha), single super phosphate (SSP) (400 kg/ha), urea (400 kg/ha) and a control (no application) on the field establishment and yield of *Gnetum africanum* plantlets in Owerri, Southeastern Nigeria. The experiment was laid out in a randomized complete block design (RCBD) and replicated three times. Results showed that using kitchen ash and poultry manure at 2400 kg/ha respectively had significantly ($P \leq 0.05$) higher number of *Gnetum africanum* plantlet establishment in the field than the other treatments 16 weeks after transplanting (WATp). The plantlets also had higher number of new leaves and number of plant survival at the end of the experiment. Vine length, number of branches and leaf area were not significant. However, yield increased as the *Gnetum africanum* plants grew and branched profusely. Plants in plots amended with poultry manure, kitchen ash, and SSP had higher yields and monetary returns than the remaining plants in plots treated with urea, and the control. The implications for improved means of rural livelihood were discussed. [Life Science Journal. 2008; 5(2): 63 – 69] (ISSN: 1097 – 8135).

Keywords: kitchen ash; organic and inorganic manure types; field establishment and yield; *Gnetum africanum* plantlets

1 Introduction

Vegetable forms an indispensable part of the human diet the world over as important sources of vitamins, minerals and proteins. Vegetable consumption is of great importance especially in the tropics where the diet is often poor in animal protein due to high cost. However, a lot of known traditional vegetables are under exploited and non-domesticated (Schippers, 2000). Such traditional vegetables such as *Gnetum africanum* (Okazi), *Gongronema latifolium* (Utazi), *Piper guineense* (Uziza) and *Vernonia amygdalina* (Olugbu or Onugbu) are good sources of minerals and local herbs used in rural community medicine (Okafor, 1995; World Bank, 2002). These leafy traditional vegetables are available at strategic periods in the year when the conventional and cultivated vegetables are scarce (Okafor, 1979).They therefore contribute significantly to the food security and nutritional well being of the rural people.

Gnetum africanum (Okazi) is a traditional vegetable consumed by many Nigerians. Currently it grows in the wild with only limited domestication. Due to its social, cultural, medicinal, nutritive and economic values, this forest vegetable plays a key role in the livelihood of most rural and even urban communities of southeastern Nigeria. It is a non-timber-forest product commonly known in southeastern Nigeria as "Okazi" by the Igbo and Afang by the Efik/Ibiobio tribes. *Gnetum africanum* is one of the several edible indigenous non-woody vegetable plants that could be taken in raw state as salad or cooked as the major vegetable of soups (Okafor, 1983). Presently, consumer demand for *Gnetum africanum* is high in our local markets and outstrips supply. It is hoped that any

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investment tailored towards improving its production will be highly rewarding. In the future *Gnetum africanum* is expected to attain the status of *Telfairia occidentalis* in volume of production.

Manure, whether organic or inorganic helps to enhance plant development and yield. The major purpose of manure or fertilizer application is to improve soil fertility and increase yield of crops. In crop production, proper and adequate plant nutrients are required for an enhanced crop establishment, growth and yield. However, crop production can be influenced by the source of nutrient involved in its production (Hodge, 1982).

In Nigeria, there is an increasing awareness of the use of fertilizers either organic or inorganic in the production of vegetables. The large consumption of vegetables in rural and urban communities in preference to the expensive and inadequate animal proteins ensures a balanced dietary food values. The rapid deforestation of forest in Southeastern Nigeria has necessitated the need to conserve some of these threatened forest products such as *Gnetum africanum*, to avoid its extinction and loss from our biological and vegetable collections (Okafor, 1995). Presently communal production of some of our indigenous vegetables such as *Gnetum africanum* has not been given adequate attention. However protected species seem to thrive on burnt trash and organic manure heaps.

Based on all these, an initiative was taken to conduct this experiment on the effect of kitchen ash, organic and inorganic manure on the field establishment of *Gnetum africanum* plantlets in Owerri Southeastern Nigeria.

2 Materials and Methods

The experiment was carried out at the Teaching and Research Farm of the School of Agriculture and Agricultural Technology, Federal University of Technology Owerri (FUTO), located between latitude 5º23'8.7" – 5º22' 59.2" N and longitude 6º59'39.4" – 6º59'40.8", on elevation of 57 m (GIS location observation of the farm site). It was established in April 2003 and lasted till August 2005 (4 months i.e. 16 weeks was used for the field establishment while 2 years was used to manage the crops in the field). Owerri is in the heart of the rainforest zone of southeastern Nigeria. The mean annual rainfall measured at the meteorological station in FUTO was 1953 mm and mean annual temperature and relative humidity during the study period were 30 ºC and 88% respectively. The soils were predominantly Ultisols and are strongly acidic, coarse textured and highly leached upland soils, which occur further south of southeastern Nigeria (Eshett, 1993). The site previously used for raising fluted pumpkin/pepper was left fallow for one year before the experiment. The soil physical properties showed that the site has 93% sand, 2.90% silt and 4.10% clay particles respectively. The soil chemical analysis carried out at the beginning and end of the experiment to determine the fertility status of the soil in the different plots of the experiment (Table 1).

The experimental site was manually cleared in April 2003 and the dry matter packed off the field. The field layout was a randomized complete block design replicated 3 times. Each experimental plot measured 2 m × 1 m (2 m^2) with one meter gap between plots. Sunken beds were used in the experiment. The yield (leaf) lasted for two consecutive years.

The 5 treatments consisted of: (1) control (no manure used); (2) ash (2400 kg/ha); (3) poultry manure (2400 kg); (4) single super phosphate (SSP) (400 kg/ha); (5) urea (400 kg/ha).

2.1 Transplanting to the experimental field

Forty-five plantlets of *Gnetum africanum* were bought from a local *Gnetum* nursery farmer and transplanted to the experimental plots a day later. The height of the plantlets at planting was 15 cm. Plantlets were planted in rows on sunken beds at spacing of 50 cm apart. There were 3 plantlets per bed giving a total of 45 stand for the experiment. Management practices include band application of fertilizers four weeks after transplanting (4 WATp) and manual weeding with hoes at 5 weeks intervals. The plantlets were mulched (shaded) with palm fronds to reduce moisture loss and sun scotching of young plantlets.

2.2 Parameters measured

The parameters measured included plant height, rate of new leaf proliferation per plant, vine length, number of branches and number of surviving plants after the field establishment phase of the experiment and the leaf area was calculated. Vine length was measured using a rule starting from the node of the youngest vine to the apex where new leaves were formed and three plants were measured and averaged.

The numbers of branches were obtained by counting the number of branches from three plants/plot and averaged to find the mean.

The leaf area (cm^2) was obtained by measuring 5 leaves each from 3 plants in each plot from the base of the petiole to the apex of the leaf to obtain the length and at the middle where the leaf was broadest to obtain the width. Thereafter, the length and width from the leaves were multiplied to obtain the mean leaf area (cm^2).

The plant height of *Gnetum africanum* was measured with a ruler at 4 weekly interval starting from 8 WATp. This was taken from the base to the tip of the last leaf (i.e. 8, 12 and 16 WATp).

The rate of new leaf proliferation per plant was taken by counting fully opened new leaves per plant at two weeks interval starting from 8 WATp. The number of *Gnetum africanum* plants that survived were counted plot by plot and recorded after the experiment.

2.3 Yield data

The management of the crops continued for 2 years. Harvest was done every 12 weeks after the establishment (16 WATp). The vines with leaves from each plot were harvested with sharp knife and weighed.

Market prices on *Gnetum africanum* leaves were got through market surveys conducted both at the farm gate and markets around Owerri in 2003/2004 and 2004/2005. Monetary returns on the yield kg/ha·month was calculated.

2.4 Data analysis

Data were analyzed using the analysis of variance (ANOVA) table for a randomized complete block design. Means were separated using Least Significance Difference (LSD). Some results were presented using histograms.

3 Results and Discussion

Figure 1 indicated plant height at different manure rates. Application of single super phosphate (SSP) gave the tallest plant height of 19.8 cm at 8 WATp when compared with poultry manure, kitchen ash and urea. At 12 WATp, application of kitchen ash and urea gave the tallest (25 cm) and shortest (16 cm) plants respectively. Similar pattern was observed at 16 WATp. However, kitchen ash, poultry manure and SSP had more significant influence on *Gnetum* plantlets than other soil amendments.

The improved effect of kitchen ash could be attributed to the liming effect and probable high nutrient release (macro and micro nutrients) needed for optimum crop growth. The performance of the poultry manure could be attributed to the mineralization (complete decomposition) of the poultry manure and release of the needed crop nutrients it contains.

In Table 1, it showed the soil chemical properties before and after the experiment. However, the physical properties of the site indicated it is naturally sandy, with 93% sand, 2.9% silt and 4.1% clay particles. It could be that the large pore space allowed the urea to leach away fast down the drains giving rise to high %N (0.31) at 0 – 30 cm soil depth after the experiment in plots treated with urea and more so causing soil acidity (pH 4.16). That urea application did not perform well in this experiment at the establishment stage could be attributed to the soil physical properties, which are sandy with large pore space that allowed fast nutrient seepage away from the plant root feeding area (Sara, 2005). Eshett (1993) described soils of Southeastern Nigeria as Ultisols and strongly acidic, coarse textured and highly leached upland soils. These characteristics do not favour the fast establishment of young seedlings, with tender roots or trying to develop young roots and could account for why the kitchen ash and poultry manure gave a good establishment background for the *Gnetum* plantlets.

The Table 1, showed increase in % total soil N in plots treated with urea, poultry manure, kitchen and SSP while the control declined from 0.07% N before the experiment to 0.05% N after the experiment indicating that N utilized during growth and production (vine elongation, leaf and bud development) were not replenished. Because the kitchen ash application served as liming material to the soil as well as manure, the soil pH improved from 5.00 before the experiment to 6.41 after while the control plots and those treated with urea declined to 4.16 and 4.99 respectively. Plots treated with SSP had increases in soil P after the experiment from initial 14.53 ppm to 29.40 ppm after the experiment. There were insignificant or no decline in Ca Cmol/kg while K Cmol/kg declined in all plots after the experiment except in plots treated with SSP (Table 1). However, there were increases in Mg Cmol/kg after the experiment except in plots treated with urea and the control.

The effect of soil amendments at various growth stages on percentage leaf proliferation and survival of *Gnetum* plantlets at 8, 12 and 16 WATp is presented in Table 2. Results indicated that at 8 WATp, kitchen ash and poultry manure had higher number of new leaves per plant than other treatments. Similar trends were observed at 12 and 16 WATp with the application of kitchen ash and poultry manure. Accordingly, they had 7.5 and 6.36 number of new leaves respectively and were significantly different ($P \leq 0.05$) from plantlets treated with urea application. Leaf proliferation did not differ significantly ($P \geq 0.05$) between poultry manure, kitchen ash, SSP and control but with urea. This could be attributed to the decline in the number of plants or death of plantlets in plots treated with urea. Urea being a single fertilizer its addition to the soil lowered the soil pH from 5.00 before the experiment to 4.16 after the experiment (Table 1) making the soil acidic, thus resulting in scotching of the young roots of the *Gnetum africanum* plantlets. This is in line with the findings of Michael and Muns (1996) that in nutrient interactions

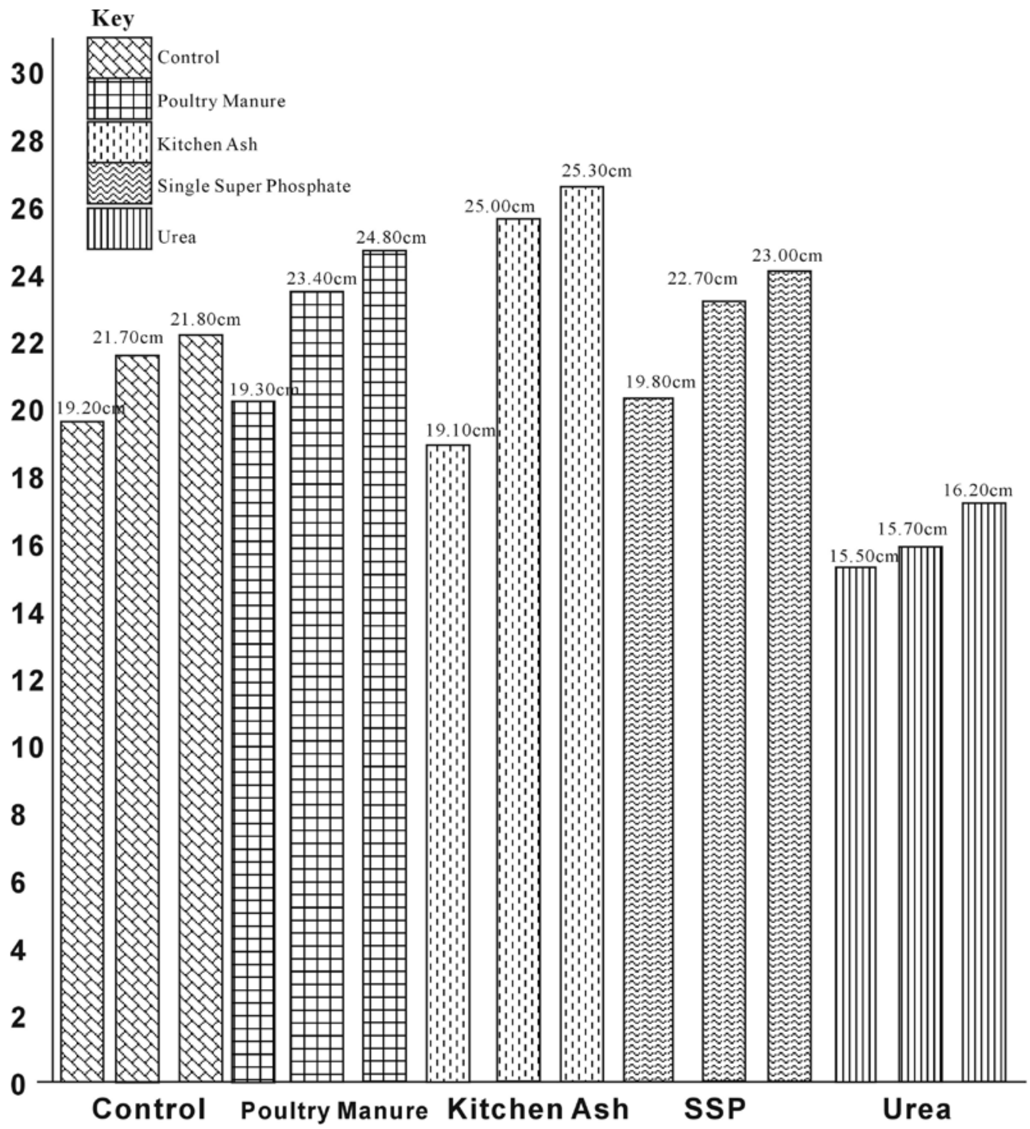

Figure 1. Mean *Gnetum* plant height 8, 12 and 16 WATp

Table 1. Soil chemical properties before and after the experiment

	N (%)	P (ppm)	K (Cmol/kg)	Organic matter (%)	Organic carbon (%)	Ca (Cmol/kg)	Mg (Cmol/kg)	pH (H_2O)
Before experiment (0 – 30 cm)	0.07	14.53	0.50	2.30	1.34	0.64	0.52	5.00
After experiment (0 – 30 cm)								
Control	0.05	10.64	0.49	2.25	1.26	0.59	0.51	4.99
Poultry manure	0.16	15.30	0.49	2.45	1.86	0.64	0.54	5.16
Kitchen ash	0.09	13.80	0.48	2.45	1.35	0.64	0.61	6.41
SSP	0.08	29.40	0.63	2.27	1.33	0.64	0.71	5.20
Urea	0.31	14.66	0.50	2.34	1.36	0.46	0.51	4.16

when the effect of one factor depends on the level of another, the two factors are said to interact, but in general more benefit is obtained from the input if these factors are improved, the better the plants can grow and the more it will respond to fertilization with a limiting nutrient. The reverse is the case in this situation since the interaction left most of the plantlets scotched to death.

Gnetum plantlets, which received kitchen ash, had the highest survival percentage (78%) followed by poultry manure treatment (56%) while SSP and the control had 44% each and urea 22%. This indicates that in an environment like Owerri that is dominated by highly leached soils (Ultisols) kitchen ash and poultry manure can be used for effective soil amendment and proper field establishment of *Gnetum africanum* plantlets. This is because the kitchen ash is expected to reduce the acidity of the soil on which it is applied thereby making the soil environment suited for good plant establishment. This is in line with the findings that ash is made up of many major and minor elements needed for plant growth. Furthermore, they acknowledged that ash is a neutralizing agent often used in lowering soil pH for good plant nutrition and establishment. Poultry manure repairs the disaggregated soil particles by binding them together and releasing the essential plant nutrients gradually for effective plant growth and productivity. This might be the reason why 56% of the plantlets survived. This agrees with the fact that slow release of nitrogen to the soil supplies the correct amount throughout the cropping season and this is one of the desirable features of an arable soil (Howard, 1997). With the application of poultry manure more nutrients especially N, P, K, Ca and Mg will be available for plant use.

Mean vine length of plant treated with kitchen ash and poultry manure were longer than those treated with SSP, urea and the control (Table 2), although there were no statistical significant differences. The mean number of branches was not statistically significant, the *Gnetum* plantlets produced 1 to 4 branches between 8 and 16 WATp (Table 3). The branch development was slow. The leaf area was not statistically significant. Since the plantlets were got from the same garden, it might be that they are from the same species or sub species and the little differences could be attributed to nutrient release and uptake of the individual plantlets that enabled their leaves to be a little wider than of the others.

The yield data showed a progressive increase in the number of leaves as the branches increase as they develop. Table 4 showed the yield and monetary returns of the *Gnetum africanum* over a period of 2 years harvested every 4 weeks after establishment. The yield of the *Gnetum africanum* increase as the plant gets older in the field.

Table 2. Percentage of survival leaf proliferation at 8, 12 and 16 WATp

Treatment	Survival (%)	8 WATp	12 WATp	16 WATp
Control	44	2.50	3.80	5.30
Poultry manure	56	3.70	6.20	6.36
Kitchen ash	78	3.70	7.00	7.50
SSP	44	3.40	4.90	5.70
Urea	22	1.60	2.40	2.60
LSD ($P \leq 0.05$)	19.16	2.00	3.62	3.76

Table 3. Mean vine length growth (cm) at 8, 12 and 16 WATp

Treatment	8 WATp	12 WATp	16 WATp
Control	1.78	2.95	3.11
Poultry manure	4.89	6.50	8.98
Kitchen ash	4.87	6.85	8.95
SSP	1.71	3.25	4.60
Urea	1.05	2.15	3.00
LSD ($P \leq 0.05$)	NS	NS	NS

However, the results indicated that manure or soil amendment is very necessary in *Gnetum africanum* production. Also, shade is very important as it helps to produce plants with broad leaf area. Broad *Gnetum* leaves attract buyers and gives higher monetary returns since marketers prefer broader *Gnetum* leaves than narrow one (Schippers, 2000). There were higher yields in 2004/2005-production season than the 2003/2004 season and higher monetary returns since prices were increased as a result of increase in *Gnetum* leaf demand and also with the trend of economic growth in the country. Plots treated with poultry manure and kitchen ash had higher monetary returns of N507000 and N499200 per annum respectively in 2004/2005 season than those treated with SSP, urea although not significantly different among themselves but were significantly different from the control (Table 4). This indicated that a farmer can comfortably produce *Gnetum africanum* since yield increases as the plant aged and scatter its roots for extensive nutrient uptake and usage.

Field observations showed that the applied soil amendments maintained limited solubility as some fertilizer granules were still intact several weeks after application especially the SSP. It may be that phosphorus was partially fixed or occluded since they did not decompose completely thus having high quantity of P left in the soil after the experiment (Table 5). Since the experiment lasted for 16 weeks in the first instance and then continued for two years to obtain the yield, it is expected that existing natural release of nutrient from the soil did not favour the fast establishment of *Gnetum africanum* plantlets but the effect thereafter showed on the yield (Table 4). It means that for *Gnetum* survival, growth and establishment the soil must have high organic matter and nutrients applied must have been highly soluble for the young, plantlets to establish fast.

Appearance of new shoots and/or regrowth after harvest took 21 – 28 days. These *Gnetum* plants shed their older leaves at the beginning of the dry season in November/December followed by a boom of new leaf flush and bud emergence with shiny leaves . This might be attributed to auxin complexes in plant physiological development.

Further field observations revealed that as the roots of *Gnetum africanum* runs underground on the shallow surface beneath the ground about 3 to 5cm, it brings up new growth with roots along and these are known and called *Gnetum* plantlets. These can be used effectively for the fast establishment of the *Gnetum* plant. According to Schippers (2000) the ordinary stem cuttings grow and perform better than seed germination, which is very slow and irregular taking up to 1 year or more for the seed to geminate. During the management period of 2 years the adult plant developed a lot of branches and leaves.

Furthermore, we observed that most of the plants that were exposed to the direct heat of the sun, produced leaves with small leaf area while those under or near a shade plant or near the bush, had broader leaves. This observation is in line with Schippers (2000) who reported that this crop performs best in the shade or near the edge of a forest and does not grow well under fully exposed conditions and that leaves which are exposed to the sun light are much smaller and often more yellowish in colour than those in full shade.

Table 4. Mean number of branches and leaf area (cm^2) at 8, 12 and 16 WATp

Treatment	8 WATp	12 WATp	16 WATp	Leaf area
Control	1.00	1.40	2.50	15.80
Poultry manure	1.92	2.10	3.48	20.90
Kitchen ash	1.86	2.45	3.50	18.90
SSP	0.86	1.60	2.75	18.30
Urea	0.50	1.50	1.55	20.20
LSD ($P \leq 0.05$)	NS	NS	NS	NS

Table 5. Yield and monetary returns in bundles (kg/ha·month) of *Gnetum africanum* 2003/2004 and 2004/2005

Treatment	Yield (kg/ha·year)		Monetary returns /Annum (N & K)	
	2003/2004	2004/2005	2003/2004	2004/2005
Control	432[b]	540[b]	246240[b]	351000[b]
Poultry manure	708[a]	780[a]	403560[a]	507000[a]
Kitchen ash	684[a]	768[a]	389880[a]	499200[a]
SSP	624[a]	732[a,b]	355680[a,b]	475800[a,b]
Urea	588[a]	720[a,b]	335160[a,b]	468000[a,b]

Columns with the same letter (s) are not significantly different from one another according to Duncan's Multiple Range Test.
Mean market surveys in 2003/2004 at Owerri main market (N, 710) Nkwo ukwu Ihuagwa (N, 480) and Afor Enyi-Ogwugwu (N, 520) = N, 570.00/kg.
Mean market surveys in 2004/2005 at Owerri main market (780) Nkwo ukwu Ihiagwa (570) and Afor Enyi ogwugwu (600) = N650.00/kg.

4 Conclusion

The findings showed that kitchen ash and poultry manure (2400 kg/ha) performed better in the field establishment of *Gnetum africanum* plantlets in Southern Nigeria. For an enhanced field establishment of *Gnetum africanum*, the soil pH must be at least near neutral and enough organic manure should be supplied for fast nutrient release to the seedlings or plantlets as the case may be.

It is suggested that further studies be conducted on *Gnetum africanum* in order to obtain a better understanding of the growth and agronomy for its domestication. Also, trials should be carried out on soil nutrient dynamics as well as other indigenous crops such as *Gongronema latifolium, piper guineense, Vernonia amygdalina* etc.

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