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Nutrient Potentials of Some Indigenous Multi-Purpose Tree Species in Soil Fertility Management of Agroforestry Farms in Akwa Ibom State, Nigeria

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ABSTRACT

Nutrient potentials of leaf litters of three commonly cultivated multipurpose trees - Dacryodes edulis (G. Don, H. J. Lam)., Chrysophyllum albidum,(G. Don) and Irvingia gabonensis (O' Rorke) Baill were investigated in Akwa Ibom State. The leaf litters were composted in open soil pits covered with netting materials in the Forestry Department Experimental Farm. The experimental design was the completely randomised design in three replicates. The litters were allowed to decompose and cure by aerobic process for a period of 9 months. The cured manure were analysed for soil nutrients using Association of Official Analytical Chemist (AOAC) methods. The results revealed that I. gabonensis had the highest macro and micro nutrients yield totalling N(19.90mg/kg), P(2450mg/kg), K(2696.25mg/kg), Ca(1744.3mg/kg), Mg(993.13mg/kg), and Zn(94.38mg/kg), Mn (80.50mg/kg), Cu (7.0mg/kg), B(0.25mg/kg) and Fe(1400mg/kg). It was closely followed by C. albidum with total N(14.10g/kg), P(2387.5mg/kg), K(3985.0mg/kg), Ca(1908.13mg/kg), Mg(1105.23mg/kg), Zn(92.75mg/kg), Mn(21.0mg/kg), Cu(56.38mg/kg) B(0.75mg/kg), and Fe (1320mg/kg) and lastly, D. edulis yielded a total N(19.3g/kg), P(1550mg/kg), K(4222.5mg/kg), Ca(1929.3mg/kg), Mg(1270mg/kg), Zn(74.50mg/kg), Mn(69.13mg/kg), Cu(16.38mg/kg), B(0.50mg/kg), and Fe(1133.10mg/kg). In all, I. gabonensis yielded the highest significant (P= 0.05) macro and micro nutrients to the soil, the highest organic carbon, but the least moisture content. This was followed by D. edulis which yielded a significant organic carbon with C. albidum yielding the least significant (P= 0.05) nutrients to the soil. It is concluded that these multi-purpose trees have great potentials for adding substantial amount of nutrients to the soil for planting in agroforestry farms and thus sustains crop production in the state.

Keywords: Agroforestry, multi-purpose trees, leaf litters, nutrient content, soil fertility.

INTRODUCTION

Inadequate land for agriculture and forestry purposes has necessitated the need for agroforestry as a compromised land use practice between forestry and agriculture (Adegbehin and Igboanugo, 1990). Most people in rural communities of Akwa Ibom State, Nigeria depend primarily on forest resources for their existence and survival. The people had been practicing shifting cultivation where the land is slashed and burnt and cultivated for one to two years, and thereafter abandoned to fallow for about four years before it is cultivated again. However, with a steady increase in population of about 4 million people which is growing at 3% per annum (NPC, 2007), this farming practice is no longer sustainable in the state. Scarcity of agricultural land has forced these subsistence farmers to cultivate hitherto baren lands, even on steep slopes. This has exposed the land to all forms of degradation including erosion, siltation of water bodies, and declining soil productivity.

Agroforestry is a collective name for land use system and technologies where woody perennials (tree, shrubs, palms, bamboos, etc) are deliberately used on the same land management units as agricultural crops and/or animals in some forms of spatial arrangement or temporal sequence (Adedire, 2005). Thus, agroforestry which incorporates forest trees and farm crops and sometimes, animal on the same piece of land has been considered a better alternative to shifting cultivation. This is borne out of the fact that leaf fall and animal waste under the warm tropical climate will decompose into humus, by the action of microorganisms, and add to the fertility of the soil for enhanced productivity.

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The amount of humus in soil varies from 1-30% (Uno *et al.*, 2001). The amount of humus in soil affects soil properties and the plants in several positive ways. Light-weighted spongy textured humus increase the water retention capacities of soils and slows down runoff (Uno *et al.*, op.cit). Humus provides habitats for many soil organisms that mix and concentrate nutrients in the soil; and most plants grow best in soil containing 10-20% humus (Thevathasan, *et al.*, 1997). The nutrients input of humus from decomposed leaves to soil fertility per unit area is far much richer, cheaper and more readily available than plant nutrient from inorganic fertilizer (Thevathasan *et al.*, op.cit*).* According to Parker and Corbitt (1992), the tropical humid forest which is the most productive and most luxuriant vegetation in the world, grows on very poor soils which is made rich by humus. The presence of foliar humus in the soil creates soil voids which are conduits by which needed soil air reaches the roots of plants and also enhance the penetration of water in soils thereby stimulating plant growth (Parker and Corbitt, op.cit).

Against this background, a study was conducted to investigate the nutrient potentials of the leaf litters of three indigenous multipurpose trees – *Dacryodes edulis* (C. Don. H. J. Lam) (African pear), *Chrysophyllum albidum* (C. Don) (African star apple), and *Irvingia gabonensis* (O'Rorke) Baill (Bush mango), for adoption in Agroforestry farms in Akwa Ibom State to enhance soil fertility and environmental conservation.

METHODOLOGY

Study Area

Akwa Ibom is one of the 36 states in Nigeria and is situated between latitudes 4^0 32^1 N and 5^0 33^1N and longitudes 7^0 25^1 E and 8^o 25^1E with a total land area of 8,412 km^2 (Akpan-Ebe, 2015). The State has an annual rainfall range of 1800-3500mm and a monthly mean temperature of 26.5^0C. It lies wholly within the Cross River Basin in the south eastern corner of Nigeria and sits on the Atlantic Ocean with a coastline of about 129km long (Akpan-Ebe and Amankop, 2001). It has two seasons in a year **-** the dry season beginning from November to March and the wet season from April to October.

The topography is generally flat with sandy coastal beaches. The highest elevation of about 150m asl is found at Obotme towards the northernmost part of the State in Ini Local Government Area, while the lowest of about 15m asl occur in the south along the Atlantic coastland. There are four discernible ecological zones which are highly productive but sensitive and fragile ecosystems. These are mangrove swamp forest along the coast, fresh water swamp forest and lowland rainforest to the hinterland, and derived savanna which is a mosaic of oil palms and farm regrowth (Akpan-Ebe and Amankop, 2001) found at the northern end of the State.

The State as at 2006 had a population of 3.9 million and a population growth rate of 3.0% per annum (NPC, 2007). The majority of the population lives in the rural areas and their predominant occupation is subsistence farming which yields very little financial returns partly because of exhausted agricultural lands from repeated farming on the same piece of land.

Research Design and Data Collection

Leaf litter of *Dacryodes edulis, Chrysophyllum albidum* and *Irvingia gabonensis* aged 5 to 20 years were randomly collected from homestead gardens across the State. Litter from each species was stored separately in black plastic bags and taken to the Forestry and Natural Environmental Management Department Experimental Farm, University of Uyo, where the experiment was conducted. One kilogramme of leaf litter from each of the three species was weighed out separately, chopped and deposited in soil pits, measuring 20cm x 10cm x 15cm prepared for the experiment. The pits were covered on top with fine mesh netting materials to allow free flow of air in the pits and also prevent extraneous litter from mixing and interfering with the experiment. The litter in each soil pit was carefully mixed together once a week to aid uniform decomposition under the prevailing weather conditions with mean monthly temperature of 26.5^0C, 2000mm of annual rainfall and relative humidity of 85%. The experiment lasted 9 months, from February to October 2010. The leaves within this duration had fully decomposed, and cured by aerobic process to form humus. The experimental design was the Completely Randomized Design in three replicates. Samples of the cured humus were scooped with hand trowel, weighed, and 1 kilogram each of the respective samples was stored in a clean black polythene bag and taken to the Department of Soil Science and Land Resources Management laboratory for mineral nutrient analysis. Before the commencement of the experiment, soil samples were augured from the sampling points at a depth of 0-15cm and taken to the laboratory for soil analysis to serve as control.

Proximate and Data Analysis

The samples were analyzed for plant nutrients – nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), and magnesium (Mg); and micro elements – boron (B), iron (Fe), zinc (Zn), manganese (Mn) and copper (Cu). Macro–nutrients were determined by flame photometry as described by the A.O.A.C. (1975). The micro-nutrients in the digest extracts were read using an atomic absorption spectrophotometer (Model UNICAM 939). The soil pH was measured in 1:2 soil-to-water suspension with a glass electrode pH metre. The Electrical Conductivity (Ec) of 1:2 soil-to-water extract was measured at 25^{0}C with a conductivity metre. The soil moisture was determined using Stuart Scientific Oven 252, dried at 105^{0}C for 24 hours. Data obtained from the experiment were subjected to Analysis of Variance, and the least significant difference (LSD) used to compare the means.

RESULTS AND DISCUSSION

Results

Soil characteristics at 0-15cm depth before the commencement of the experiment, which served as the control, and the nutrients (macro and micro) yield of the humus from the respective decomposed leaf litter of the three selected multi-purpose trees (MPTs) after 9 months of full aerobic decomposition are presented in Table 1.

Table1. *Soil mineral nutrient content of the experimental site (the control) and macro and micro nutrients yield of the litters of D. edulis, C. albidum and I. gabonensis*

Soil and Litter sample	N (g/kg)	P (mg)	K (mg)	Ca (mg)	Mg (mg)	Zn (mg)	Mn (mg)	Cu (mg)	B (mg)	Fe (mg)	Organic Carbon (g/kg)	Ec (ds/m)	pH	Moisture content
D. edulis	19.30	1550.00	4222.50	1929.25	1270.00	74.50	69.13	16.36	0.50	1133.10	370.6	0.39	5.40	33.00
C.albidum	14.10	2387.5	3985.00	1908.10	1105.40	92.75	21.00	56.40	0.75	1320.00	160.50	0.29	5.70	23.00
I.gabonensis	19.90	2450.00	2696.30	1744.30	993.10	94.40	80.50	7.00	0.25	1400.00	390.00	0.39	5.90	22.60
Soil(Control) (0-15cm depth.)	0.50	268.50	102.10	1128.50	814.00	33.70	25.90	1.30	0.01	1023.00	886.40	0.42	5.80	21.60
T. test (0.05)	0.01	0.02	0.02	0.00	0.01	0.01	0.01	0.25	0.009	0.004	0.10	0.000	0.002	0.16

Results revealed that *I. gabonensis* yielded the highest significant (P=0.05) Nitrogen (19.9g/kg) compared to the soil (0.50g/kg). This was followed by *D. edulis* (19.3g/kg), while *C. albidum* yielded the least (14.10g/kg). Table 1 shows also that with equal amount of humus, *I. gabonensis* added more phosphorus (2450mg/kg) to the soil, followed by *C. albidum* (2387.5mg/kg), and *D. edulis (*1550.0mg/kg) when compared with that of the control (268.5mg/kg) at 0-15cm soil depth.

D. edulis added significantly highest (P=0.05) K content (4222.5mg/kg) and, thus yielding much more K to the soil when compared with the control (102.10mg/kg). This was followed by *C. albidum,* (3985mg/kg) and the least addition of K to the soil from *I. gabonensis* (2696.3mg/kg). *C. albidum* and *D. edulis* yielded about the same amount of Ca (1929.25mg/kg and 1908.1mg/kg, respectively), compared to the soil (1128.5^{0}mg/kg), while *I. gabonensis* yielded the least calcium (1744.3mg/kg) among the tree species.

Micro nutrient yield indicated that *I. gabonensis and C. albidum* had about the same quantity of zinc (94.4.mg/kg and 92.75mg/kg, respectively) and this was more than 100% zinc content of the soil (33.70mg/kg), while *D. edulis* added the least Zinc (74.50mg/kg) to the soil (Table 1). *Chrysophyllum albidum* yielded the significantly highest (P=0.05) copper (56.4mg/kg) to the soil followed by *D. edulis* (16.38mg/kg) and the least was from *I. gabonensis* (7.0mg/kg).

Among the tree species (Table1), *C. albidum* added the highest amount of boron (0.75mg/kg) followed by *D. edulis* (0.5mg/kg) while *I. gabonensis* added the least (0.25mg/kg) compared to that of the soil- control (0.01mg/kg). The three tree species yielded about the same quantity of Fe (*D. edulis* (1133.10mg/kg), *C. albidum* (1320.0mg/kg) and *I. gabonensis* (1400mg/kg)) to the soil. *Irvingia gabonensis* yielded the highest (p=0.05) content of manganese (80.50mg/kg), followed by *D. edulis* (69.3mg/kg) and *C. albidum* (21.0mg/kg). The order of organic carbon content in the leaf litters of the three tree species were: *I. gabonensis*, (390.0g/kg), *D. edulis*, (370.6g/kg) and *C. albidum* (160.5g/kg).

The variation in electrical conductivity of the litter of the three tree species was not significant (P=0.05). There was a significant (P=0.05) difference in moisture content among the leaf litters compared to the soil with *D. edulis* having the highest (Table 1).

The pH of the soil was modified with the addition of the nutrient rich leaf litter of the three tree species (Table 1) Litter from *I. gabonensis* was able to reduce the soil acidity from pH 5.8 to 5.9 while increasing acidity was noted with C. *albidum* and *D. edulis* litters with pH 5.7 and 5.4, respectively when compared with the control (pH 5.8). In general, *I. gabonensis* yielded the highest significant (P=0.05) nutrients content to the soil while *D. edulis* yielded the least (Table 2).

Table2. *Approximated weight content of nutrients from the leaf litters of D. edulis, C. albidum and I. gabonensis*

Leaf litter of the MPTs	N	P	K	Ca	Mg	Zn	Mn	Cu	B	Fe	Organic Carbon
D. edulis	193	1.5	4.22	19.29	12.70	0.74	0.69	0.16	0.005	11.33	370.6
C. albidum	144	2.38	3.99	19.08	11.05	0.92	0.21	0.56	0.008	13.20	160.5
I. gabonensis	199	2.45	2.67	17.44	9.93	0.81	0.81	0.07	0.003	14.00	390.5

DISCUSSION

There were significant differences in the yield of mineral nutrients by the leaf litters of the three tree species. This exceptionally high N-yield by the leaf litters of these multipurpose trees far exceeds the range of 2-4% N contents recorded by FAO (1990) in other agroforestry tree species which were cultivated in farms for their exceptional nitrogen contributions to the soils. Similarly, Etuk *et al.* (2010) recorded more N content (4.03%) in the leaf pruning, than the soil under *Lonchcarpus griffonianus*. This supports the findings that leaf prunings or leaf litters of some trees may have far higher N-yield than the soil on which they grow. These findings further support the report by ICRAF (1997) that leaf prunings or leaf litters can greatly improve soil fertility.

There was also a significant difference in the yield of phosphorus among the species with *I. gabonensis* yielding the highest compared with that of the control. This agrees with the findings of Etuk *et al*. (2010) who reported 0.2 - 0.26% P content in the leaf pruning of *Dactyladenia barteri*. Okeke and Idrissa (1998) further recorded higher levels of phosphorus in *Adonsonia digitata* (0.55%) and *Spondias mombin* (0.41%). However, *C. albidum* litter yielded about three folds the amount of P to the soil, compared to that of *Adonsonia digitata* (Okeke and Idrissa, 1998).

Dacryodes edulis added more potassium to the soil when compared with other tree species and the control (soil). This is within the range of 1-3% K levels as reported by FAO (1990). About equal quantity of calcium was added to the soil by all the three multi-purpose species. *D. edulis* added more magnesium to the soil than others. The concentration of Mg by the three species is within the range of 0.36 – 0.61% reported for *Alchornea cordifolia, Spondias mombin,* and *Milicia excelsa (*Okeke and Idrissa, 1998). Okeke and Idrissa (*op. cit)* further recorded a far higher Mg content in *Adonsonia digitata,* while Kio *et al.* (1977) reported 122, ug/g Mg from the leaf litter of *Tectona grandis.*

FAO (1990) put the nutrients use efficiency by plants between 20-30% which implies that between 70-80% of the nutrients in plant biomass are not available for plant growth since nutrient yield to plants depends on many factors such as rate of litter decomposition, leaching and wash off in runoff.

The macro nutrient (N, P, K, Ca, and Mg) contents are higher than the range reported by FAO (1990). Macro nutrients are needed by plants in relatively large quantities and are essential for plants growth, general plant developments and reproduction. Therefore, applications of litters of trees will prevent deficiency of these nutrients in plants usually manifested with symptoms ranging from chlorosis, necrosis, stunted growth, death of roots and shoot tips, susceptibility to diseases, weakness of stems, pigmentation and delayed maturity (Uno *et al.*, 2001).

Micro-nutrients concentration within the litters indicated that *I. gabonensis* had the highest Zn, Mn and Fe. This is followed by *C. albidum* while *D. edulis* yielded the least for all the three micro-nutrients. The micro-nutrients yield recorded by these leaf litters (*I. gabonensis*, *C. albidum* and *D. edulis)* are far higher compared to the range of 0.00001 – 0.01% reported by Uno, *et al.* (2001). The percentage moisture content was highest (32%) in the *D. edulis* leaf litter, while the yield of organic carbon was highest in *I. gabonensis* leaf litter.

The findings in this study revealed that large quantities of nutrients are being added to soils from leaf falls from the indigenous species thus replenishing exhausted soils. Agroforestry practices in Akwa Ibom State promote the domestication of multipurpose trees on farmlands for multiple benefits including soil conservation for sustainable food production. This confirms the report by FAO (1990) that prunings and leaf litters from some indigenous trees can add substantial amount of nutrients to their soils, thereby conserving such soils from degradation via such environmental friendly approach.

CONCLUSION

This study has shown that indigenous multi-purpose trees cultivated in the agroforestry farms, especially in homestead gardens, have great potentials of adding substantial amount of nutrients to their soils. In addition, they are also capable of recycling nutrients for higher crop yields. The variations in nutrients content of these multi-purpose tree species may be attributed to their genetic and morphological make up and of the parent material underlying their soils. Apart from the nutrients recycled, the humus-adding properties of these species, and other products from these trees, the plants have great potentials for enhanced sustainable food production.

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