FORESTRY AND ALLIED NATURAL RESOURCE DISCIPLINES IN NIGERIAN INSTITUTIONS: INPUTS FOR FUTURE SOLUTIONS TO DWINDLING FOREST ESTATE IN NIGERIA




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Preface

The 1st Commonwealth Forestry Association (CFA) 2016 , Nigeria Chapter is a follow-up to the third CFA Workshop held in October, 2015 at the Forestry Research Institute of Nigeria (FRIN), Jericho, Ibadan, Oyo State, Nigeria.

CFA, Nigeria Chapter is a non-profit association under the supervision of the CFA Headquarters, United Kingdom. Though, some Nigerians have been members since 1970s, the Nigerian Chapter of the Association was formally inaugurated on the 08 September, 2011 at the Federal University of Technology, Akure, Ondo State, Nigeria.

This is a research oriented conference that seeks to bring together forestry and allied natural resource scientists, graduates, development experts and policy makers from higher institutions and research institutes to proffer future solutions to the dwindling Nigerian Forest Estate. By standard, Nigeria is expected to have 25% forest estate with gazette notice.However, Nigeria has less than 10% forest estate.

CFA CHARTER AND BYE-LAWS

The Royal charter of 1 November 1921, as amended by Supplemental Charter of 28 November, 1962, provides that the name of the Association shall be the Commonwealth Forestry Association. The Charter and Bye-Laws which follow incorporate amendments agreed at the Annual General Meeting on 5 May, 1981 and which submitted to the Privy Council for the granting of a further Supplemental Charter.

CHARTER

The objects and powers of the Association were prescribed as follows:

i. To promote for the public benefit the practice of Forestry both in the United Kingdom and throughout the world

ii. To advance education in the value of trees and forests for the conservation of wildlife, soil and water resources, amenity and recreation

iii. To promote research for efficient and sustained production of timber resources and into the inter-relationship between trees and site fertility both for Forestry and Agriculture, publishing the useful results of such research.

iv. To encourage the establishment and management of trees and forests as part of the overall wise and sensible use of land

v. To be a centre for the exchange and dissemination of information on all aspects of forestry and forest products or provide or promote or assist in the provision or promotion of other centres similarly engaged.

The theme of 1st Commonwealth Forestry Association Confernce 2016 is '**Forestry and Allied Natural Resource Disciplines in Nigerian Institutions: Inputs for Future Solutions to Dwindling Forest Estate in Nigeria'**.

Papers presented in this proceedings, which were peer reviewed, include lead papers and voluntary papers. They are classified under the following sub-themes:

- Forest Management, Forest Investments and Agroforestry
- Environment, Climate Change, REDD+ and Bio-Energy
- Forest Ecosystems, Biodiversity and Wildlife Conservation
- Forest Governance Issues
- Issues on Tropical Inventory, Measurements and GIS
- Sustainable Utilization of Forest Products and Herbal Medicine.

The Commonwealth Forestry Association Nigeria Chapter appreciates the moral support of Executive Director, Forestry Research Institute of Nigeria in person of Dr. A. O. Adepoju for hosting the 1st CFA Nigeria Chapter Conference. The efforts of members of Local Organizing Committee (LOC) namely: Dr. O. R. Adejoba (Chairman), Dr. Olusola Adedoyin Ogunwande, Dr. Olufunmilola Atoke Williams, Oluwatobi Damilola Aba, Peter Oluwagbenga Ige , Olajumoke Abiodun Adubi, Babatunde Joseph Bamgbade, Sola Obadimu, Mr. A. O. Agbo-Adediran, Julius Adebayo, S. A. Odewo and Oluwafunmilayo Oyewale are highly appreciated.

I appreciate the immense contributions of all Executive Officers of CFA Nigeria Chapter for the success of this conference. They are Professor A. C. Adetogun (Vice-President), Dr. O. R. Adejoba (Secretary), Mr. A. O. Agbo-Adediran (Assistant Secretary), Dr. A. O. Omole (Public Relations Officer), Dr. O. V. Oyerinde (Finance Secretary), Dr. I. O. Osunsina (Social Secretary), Professor S. A. Oluwalana (Ex-officio) and Professor S. O. Akindele (Ex-officio).

Professor B. O. Agbeja

President, Commonwealth Forestry Association Nigeria Chapter

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THEME:

FORESTRY AND ALLIED NATURAL RESOURCE DISCIPLINES IN NIGERIAN INSTITUTIONS: INPUTS FOR FUTURE SOLUTIONS TO DWINDLING FOREST ESTATE IN NIGERIA

KEYNOTE ADDRESS

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1st Commonwealth Forestry Association (CFA) Conference, Nigeria Chapter

FORESTRY RESEARCH INSTITUTE OF NIGERIA (FRIN), IBADAN, OYO STATE, NIGERIA

10-12 OCTOBER, 2016

KEYNOTE ADDRESS

By

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First and foremost, I wish to thank the Nigeria Chapter of the Commonwealth Forestry Association (CFA) for inviting me to give a Keynote address on this occasion. About two decades ago, it would have been impossible for me to accept the invitation within the Nigerian contemporary context; given the celebrated Senior Forestry Officers who were also members of the CFA. In accepting this invitation, I assured myself that I would not be breaking any professional protocol on Nigerian soil.

I joined the CFA here in Ibadan in 1972 on the persuasion of the late Dr. J. F. Redhead who was then the Head of the Department of Forestry, University of Ibadan, Nigeria. However, when I was on duty at the Joint ECA/FAO Agriculture Department in Addis Ababa, Ethiopia in 1980, I signed up as a life member and remain one even uptil this moment. It is therefore, a great pleasure for me to welcome Mr. Alan Pottinger, the Secretary-General of the World-wide CFA as well as the Editor of the Quarterly Issues of the CFA Newsletters to Ibadan, Nigeria.

Now to the theme of today's conference; in particular 'Inputs for future solutions to the Dwindling Forest Estate in Nigeria. First of all, it is no longer news that each state has a Federal University and that apart from the University of Lagos, each federal university has a Faculty of Agriculture. Also, each of the 36 states has a University of her own. Again, only the Lagos State University (LASU) does not have a forestry-related faculty. Thus, there are now about 40 forestry-related programmes in Nigerian Universities.

However, this conference is intended to deliberate on viable contributions which erstwhile civil service forest managers ought and should make with inputs from the training institutions to the terribly inadequate public forest estate of today. In doing this, permit me to briefly summarize what I saw on ground 52 years ago when I came from the London School of Economics and Political Science, University of London on an 8-month- field work to the then Western and Midwestern forest services. Each region had senior headquarters staff who supervised the field activities and reported to the Chief Conservator of forests. The headquarters main units comprised: forest inventory; forest protection (i.e. forest offences, court cases, supervision of the uniform staff, etc.); detailed forest revenue; records; maps of each forest estate; etc.

As of today, those two regional governments have been constituted into eight states; each state has its own forestry department with a multitude of directors in the forestry ministry with non-foresters as chief executives. Take for instance, Ekiti State, probably the second smallest state in Nigeria with only a negligible forest estate! Forestry is now the dominant partner in the Ministry of Environment which has five Directors of Forestry. Ondo State with some considerable forest estate has five Directors, while Osun State has three Directors; the most senior of them is a non-forester. Ogun State has a Ministry of Forestry with three departments; the most Senior Director is, again, a non-forester. In summary, the situation in each of these states brings into focus the unsustainable fiscal burden on the patently inadequate and over-exploited forest estate.

In a brief interaction with some of the 'grandiose directors', their fulfillment was that forestry had obtained independence with only a tenuous assurance of being able to supply a modicum of pertinent goods and services in the long term. I then enquired if they had even taken a proposal on land acquisition for forestry development to the government in the last ten years. The pre-emptive answer again and again was that government is NOT interested in land acquisition for forestry except for housing, industrial estate, education, health facilities, etc. I then stressed the point that each of those projects is incomplete without the vital inputs of forest products. Moreover, I emphatically drew the attention of the Directors to the fact that in a renewable resource ministry such as that of forest resources, the job of the Directors is about 20 percent done with revenue collection; the more important duty with enduring impact is

to secure adequate land for plantations of desirable species on varied rotations for the consumption of the ever growing Nigerian population.

Of equal concern in this correction is the fact that the Federal Department of Forestry which has branches in every state, excluding Lagos State has no forest estate of its own; and so also is the Forestry Research Institute of Nigeria. However, 21 years ago, the Federal Department of Forestry launched a scheme through a series of studies under the erstwhile FORMECU.

On that occasion, FORMECU invited Julius Abu and myself to work on the Nigerian Forestry Action Programme, i.e. NFAP. Part I of the report ran into 267 pages. When it was finally released to the public, it was split into 2 volumes i.e. under the name of the then Minister of Agriculture and Natural Resources. The original volume II (i.e.39 pages) of the report which was, indeed, a summary of Actions (i.e. Investment Profiles) was released as the output of the then Director, Federal Department of Forestry.

To the best of our knowledge, no further actionhas ever been taken on those valuable reports,even though the aim was basically to enable both the Federal Department of Forestry and FRIN acquire and own foret estate throughout Nigeria. As of today, and of all the federations in the world, Nigeria, is regrettably, the only one in which the national i.e. federal government without an inch of its own forest land. In many countries, some local governments, indeed local councils have their own forest estate.

At this juncture, I wish to dwell briefly on a few suggestions; namely:

First, it is such a very long time that I heard of the national meeting of the Federal Department of Forestry and the State Forest Services. However, I recall that the National Committee on Forest Policy Review invited me to make a presentation pertaining to 'Inputs of Non-government Organizations to Nigerian Forest Policy' at its meeting in Abuja on 09 December, 1999. Hence, I am of the opinion that a worthwhile output of this CFA Conference is for the Executives to formally introduce themselves to the Director, Federal Department of Forestry in Abuja who is the statutory Chairman of the Conference of Federal and State Forest Officers in Nigeria. Such a communication would put him on notice for the involvement of the CFA Branch in National/State Forestry activities henceforth.

Secondly, I suggest that the Executive Officers of the Commonwealth Forestry Association (CFA), Nigeria Chapter; the Forestry Association of Nigeria (FAN); Forest and Forest Products Society (FFPS); and Association of Women in Forestry and Environment (AWIFE) should stress the profound concern for the implications of the dwindling Nigerian forest estate. The long and short term intention is for the four Associations to assist Federal and State forestry authorities in mounting fruitful interventions for substantially increasing the land area and productivity of Nigeria's forest estate.

Thirdly, CFA, FAN, FFPS and AWIFE should join forces to develop a position document (and with the active participation of Federal and State Forestry authorities) outlining the current perilous forestry situation for the urgent attention of Federal, State as well as all local government authorities for presentation and debate at a national forestry forum in the very near future.

At this First CFA Conference in Nigeria, it seems to me that too many recommendations may not necessarily be advantageous. Hence, what remains for me is to; once again, congratulate the CFA on this brilliant initiative.

I wish CFA, FAN, FFPS and AWIFE significant and productive interventions for the growth of Nigerian Forestry.

Thank you.

1ST CFA CONFERENCE, NIGERIA CHAPTER

LEAD PAPERS

Prioritising and Protecting Nigeria's Threatened Trees: The Work of the IITA Forest Unit in Promoting the Propagation and Cultivation of Indigenous Tree Species

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ABSTRACT

Headquarters of the International Institute of Tropical Agriculture in Ibadan, southwestern Nigeria, comprises 1000 ha which include a forest reserve and other patches of secondary Guinea-Congo rainforest totaling approximately 360 ha. Since 2010 there have been several projects that utilize these forest resources for conservation, research, and education. These projects carry out tree propagation and planting and have redeveloped degraded areas of the campus to demonstrate the importance of indigenous tree species for landscape, livelihoods, and biodiversity. This paper outlines the activities, skills and partnerships that arise from these projects and are now managed by the IITA Forest Unit.

Keywords: Indigenous trees, reforestation, tree propagation, seed collection, *ex situ* conservation, arboretum, IUCN Red List

INTRODUCTION

The IITA Forest Unit was set up in 2015 to manage forest areas and related assets as part of the International Institute of Tropical Agriculture (IITA). It followed on from a five-year Forest Project, initially funded for three years by the A.G. Leventis Foundation and extended a further two years. This project was titled "Enhanced Use of IITA Forest Resources at the IITA Ibadan Campus for Conservation, Research, and Education". It established a nursery, experimental plots, and ethnobotanical garden, improved forest protection and carried out reforestation and restoration of degraded forest areas. Other priorities included biodiversity monitoring, especially of flora, birds, and butterflies, and environmental education for staff, visitors, schoolchildren and students.

The international headquarters of IITA covers approximately 1000 ha and is situated in the Awba Hills, at an elevation of 186 to 240 m, to the north of Ibadan, a fast-growing conurbation (pop. >3.5 million) in southwestern Nigeria (Neuenschwander *et al.,* 2015). It is now almost surrounded by the city but when acquired from the Government of Nigeria in 1967 on a 99 year lease it consisted of secondary forest, degraded areas ('bush'), 28 villages, and smallholder fields of cassava, maize, and yam, interspersed with some cocoa and small areas of grassland created by burning. After the villagers were relocated to the purpose-built village of Shasha, the concession was enclosed by a security fence 2.4 m high and 14 km long with access roads on both sides for visibility and maintenance.

Soils are mostly shallow and acidic. The bedrock is of banded gneiss which weathers to form site-specific soils and saprolite (softened granite or gneiss) with exposed flattened outcrops that are characteristic of the landscape. Clay, quartz gravel and sand predominate in uplands, laterite on lower and middle slopes, and poorly drained clayey and sandy soils in valley bottoms. Slopes average 3 to 10% and in places are up to 25%. When trees and vegetation are cleared, organic matter is rapidly lost and soils have low water-holding capacity. Erosion is a major concern on forest access roads, trails, and other exposed areas. Aquifers are rare and groundwater is shallow and localized mostly in faults and troughs in the bedrock.

Annual rainfall in the area averages 1300 mm, falling in April, May, June, July, September and October, with markedly less in August and a pronounced dry season from November to March. Records indicate that January is usually the driest month with 3-4 mm precipitation, and that the wettest months are June and September with around 190 mm and 220 mm respectively. Daytime temperatures are 26-38°C and rarely fall below 18°C at night, except during the Harmattan, which occurs mainly in January, when dust-laden air currents flow from the north and an occasional dip to 16°C is recorded (Neuenschwander *et al.,* 2015). The Awba River runs through the campus and in 1969 was dammed to form a reservoir 2.6 km long and 0.5-1 km wide. Work then began on clearing the land for development of the built environment and fields for agricultural crop research. When this was completed, the remaining area, an estimated 300 ha, was left as a nature reserve. Recent work by the GIS Unit at IITA calculated that forest areas, which are

fragmented by roads and other areas of land use, cover 360 ha rather than 300 ha as mentioned in earlier records. The difference is due to more accurate calculations and also to reforestation.

It is difficult to assess the rate of forest regeneration over the past 45 years since villages were abandoned. However, the initial estimate of 75-100 years for the forest to attain maturity seems unlikely without assistance. Many degraded areas have few large trees and observations since 2010 indicate that these areas continue to degrade. Rainforest trees have evolved as a community and resist violent storms through 'strength in numbers'. Isolated trees are often over-burdened with climbers which add weight and increase wind resistance, making them prone to damage. *Albizia* spp. in particular have brittle wood and become unbalanced when large limbs are lost, inviting further damage; in some cases trees lose the entire crown. Former village sites remain devoid of trees, being compacted and swept clean for years and colonised by impenetrable shrubs and lianas which outcompete tree seedlings.

THE IITA FOREST

The IITA forest lies in the transition zone of Guinea-Congo lowland rainforest and is one of the few remaining and best protected patches of forest in southwestern Nigeria. It serves as a refuge for many species that were once common but have declined due to urbanisation and population pressure, and may be of importance for research into climate change due to its location at a "crossroads" of sub-Saharan forest types i.e. where rainforest meets savanna on the south-north axis, and at the westernmost limit of Guinea-Congo forest which separated from Upper Guinea forest by the Dahomey Gap in neighbouring Bénin Republic. Though not surveyed in its entirety, recorded species include 509 plants, 270 birds, 236 butterflies, 46 mammals, and 28 reptiles and amphibians. Over 150 trees species have been identified, among which the following are on the IUCN Red List (NT = Near Threatened, VU = Vulnerable, EN = Endangered, CR = Critically Endangered):

- *Afzelia africana* Sm. VU;
- *Afzelia bipindensis* Harms VU;
- *Albizia ferruginea* (Guill. & Perr.) Benth. VU;
- *Entandrophragma angolense* (Welw.) DC. VU;
- *Entandrophragma cylindricum* (Sprague) Sprague VU;
- *Garcinia kola* Heckel VU;
- *Khaya grandifoliola* C.DC. VU;
- *Khaya senegalensis* (Desr.) A.Juss. VU;
- *Mansonia altissima* (A.Chev.) A.Chev. EN;
- *Milicia excelsa* (Welw.) C.C.Berg NT;
- *Nauclea diderrichii* (De Wild. & T.Duran) Merrill VU;
- *Nesogordonia papaverifera* (A.Chev.) R.Capuron VU;
- *Strombosia pustulata* Oliv. EN; and
- *Terminalia ivorensis* A.Chev. VU.

Small areas of the IITA forest have a high diversity of plant species, providing a snap-shot of mature Guinea-Congo forest but the general picture is one of secondary forest and highly degraded areas ('bush'). The main area of forest lies on the west bank of the reservoir. It was more or less intact until the 1980s when an area was cleared for alley-cropping experiments and other agricultural research. Following about a decade of intensive use, this area was abandoned and although badly infested with *Leucaena leucocephala* (Lm.) de Witt, and to a lesser extent also by *Gliricidia sepium* (Jacq.) Kunth. ex Walp. which were not removed from abandoned alley-cropping plots, forest regeneration was well under way until 2012 when the area was cleared again for agricultural crop research projects. The west bank forest also includes a small area known as the IITA Forest Reserve which is accessed by trails. These trails were cut in 1987 by volunteers among campus staff, extending for approximately 5 km to enclose an area of 37 ha which is traversed by two watercourses.

ACTIVITIES OF THE FOREST PROJECT

When the Forest Project began in 2010 the first task was to set up a nursery for propagation of indigenous trees for planting in designated reforestation areas and degraded areas of the forest. The existing IITA nursery had been a priority in the 1970s to provide ornamental plants for landscaping the built environment but was no longer required on the same scale. Exotic plants were therefore moved to one end and rapidly the remaining space became occupied by tree seedlings. The nursery was expanded over the 5 years of the Forest Project and now has expertise in propagating about 100 indigenous trees, backed up with records of seed treatment and germination for each species. A collaborative trial began in 2011 between IITA's Yam Breeding Unit and the Forest Project to identify indigenous trees for yam-based agroforestry systems for West Africa. A total of 30 tree species were selected, based on an

erect bole to facilitate yam climbing and avoid above-ground competition. Tree species were planted using a three reps randomized complete block design, each consisting of 15 trees planted in three rows of 5 trees, each separated 3 m. Distance between trees in the row is also 3 m to give a density of 1111 trees per ha. Yams were intercropped after planting the trees. The trial was continued with the Forest Unit and the last evaluations were carried out in 2016 when the trial was closed due to changed priorities in yam research. Long term this project results in an area of reforestation which although planted on a grid will lose this rigidity over time as natural attrition and regeneration determine the composition of species.

When the Forest Project started in 2010 it took over maintenance of trails and changed management practices. Cutting of lianas is minimised to avoid a heavy burden of dead material in the canopy that increases risk of tree fall, and raking of trails was discontinued to control erosion, protect soil organisms and allow germination of tree seedlings. As a result there has been an increase is flowering and fruiting of plants beside trails and more wildlings to enrich the forest or transplant to the nursery. Gaps infested with *Chromolaena odorata* (L.) R.M. King & Robinson have been cleared and replanted with fast-growing trees such as *Cola gigantea* A.Chev., *Terminalia superba* Engl. & Diels, and *Triplochiton scleroxylon* K.Schum. Larger gaps, such as old village sites where no large trees remained, have been restored with a wider range of trees, and a rock outcrop was planted with *Hildegardia barteri* (Mast.) Kosterm., a fast-growing coloniser of this unusual rainforest habitat.

Trees along the forest trails were surveyed by the Forest Project so that typical, easily seen specimens could be labelled for educational purposes. Project staff began taking visitors on guided walks in the forest, encouraging participation by local schools, visiting researchers, and hotel guests, and producing guide books on birds, butterflies, and plants. It was also successful in establishing forest guards as part of the IITA Security Unit to reduce poaching and help with sightings of wildlife.

Large irokos occur throughout the IITA forest and isolated specimens are a conspicuous feature of agricultural plots and the built environment where they were left standing when the original forest was cleared because they were considered sacred. *Milicia excelsa* (Welw.) C.C.Berg is Near Threatened according to the IUCN Red List and may be undergoing significant decline in this area of distribution, making the IITA campus important in its conservation. The Forest Project developed a strong interest in this iconic species and named it as one of IITA's three 'flagship' species which are protected by the IITA forest, the other two being the 'P.g. plant' *Pararistolochia goldieana* (Hook.f.) Hutch. & Dalziel VU, the largest flower in Africa, and the Ibadan malimbe *Malimbus ibadanensis*, an endangered endemic bird. Project staff raised iroko seedlings in screen houses to minimise damage by the gall bug *Phytolaema fusca* and recorded DBH and GPS of 20 mature (i.e. predating establishment of the campus) female trees and 8 males.



Figure 1: An iroko *Milicia excelsa* with IITA Forest Reserve in the background. Photo: D. Bown.

As tree propagation and planting were major activities of the Forest Project and an area of farmland 2.6 km long and from 30 m to 60 m wide along the east bank of the reservoir had been allocated for reforestation, an experiment was designed at the onset to assess the effects of different ground treatments on the establishment of indigenous tree species. The purpose of the experiment was to determine if seedlings required the shade and shelter of forest understorey for optimum growth or whether they might thrive in more exposed

conditions. The ground treatment experiment was conducted in six plots, each 20 m x 30 m, along the east bank of the lake, four in a very small, highly degraded patch of forest and two in farmland that had been intensively used for crop production for over 40 years and when fallow was derived savanna dominated by giant bluestem *Andropogon tectorum* Schum. & Thonn., a grass that reaches 2 m high. The plots were given different treatments; in Plot 1 the entire area was left untouched, with canopy, understorey and invasive species intact; in Plot 2, the canopy and understorey were left intact but invasive *Leucaena leucocephala* (Lam.) De Wit was removed; in Plot 3, the tree canopy was left intact, but all understorey removed, and the ground was disc harrowed; in Plot 4, all vegetation was removed and the ground was disc harrowed; in Plot 5, the grass was mowed first then disc harrowed and subsequently weeded; and in Plot 6, the grass was left *in situ* for 'spot' planting, in which a small circle of vegetation was removed and kept weeded to delineate the planting site. Each plot was planted with 10 different indigenous tree species: *Afzelia africana* Sm.; *Bombax buonopozense* P.Beauv.; *Cleistopholis patens* (Benth.) Engl. & Diels.; *Cola gigantea* A.Chev.; *Dactyladenia barteri* (Hook.f.ex Oliv.) Prance & F.White; *Hildegardia barteri* (Mast.) Kosterm; *Pentaclethra macrophylla* Benth.; *Pterocarpus santalinoides* DC.; *Spondias mombin* L.; and *Tetrapleura tetraptera* (Schumach.&Thonn.) Taub. They were randomly chosen on the basis of being a minimum 30 cm high, having 4-5 nodes, and being available in sufficient numbers from the recently established nursery. All were raised from seed collected at IITA in early 2010 at the start of the Forest Project, with the exception of *Hildegardia barteri*, *Spondias mombin*, and *Bombax buonopozense* which were wildlings, the first two collected in IITA forest and the last from Osogbo, Osun State.

The planting plan was random, using five plants of each species per plot. Planting positions were recorded by GPS and initially marked by bamboo poles 3 m high. The poles were later replaced by permanent engraved labels, each with a unique number so that trees can always be identified in the future for experimental purposes. Soil samples were taken from each plot, as were light readings at ground level. Planting holes 75 cm deep, back-filled with topsoil to a depth of 30 cm, were prepared and trees planted on 25 August 2010. Records were kept at regular intervals comparing growth, health and vigour of seedlings of the same species in each treatment area. Final sets of data, including light readings and soil samples, were collected in late 2013 before the end of the Forest Project.

Results, which were given in reports to the donor, indicate that young trees grow much faster in full light and with no competition from other woody plants than in dense shade of the forest understorey. This information was confirmed through extensive reforestation areas on east and west banks of the reservoir, on former dump sites, and in forest areas where over 5000 trees of 45 species were planted in four successive rainy seasons. Detailed records were kept of survival and growth rates for different species, providing valuable information to nursery staff in advising and supplying young trees for tree planting schemes.

During the final year of the Forest Project an overgrown area adjacent to the nursery was cleared and designed as an Ethnobotanical Garden to display useful plants of Yorubaland. A wide range of medicinal, spice, and fruit trees were planted, including stoolwood *Alstonia boonei* De Wild, star apple *Chrysophyllum albidum* G.Don, native pear *Dacryodes edulis* (G.Don) H.J.Lam, velvet tamarind *Dialium guineense* Willd., bush mango *Irvingia gabonensis* (Aubry-Lecomte) Baill., African nutmeg *Monodora tenuifolia* Benth., African breadfruit *Treculia africana* Decne., and African pepper *Xylopia aethiopica* (Dunal) A.Rich.

THE FOREST UNIT'S PROJECTS AND ACTIVITIES

The Forest Unit is currently responsible for implementing four projects, two of which are concerned with the conservation of trees and forests in Nigeria. The first is a three-year project, funded by the A.G. Leventis Foundation, which will develop the derelict IITA Arboretum as a Tree Heritage Park for ex situ conservation of indigenous trees, education and research. The Arboretum was established in 1991 as a collection of multi-purpose trees for agroforestry systems. The area was divided into plots containing 180 different tree species, both indigenous and exotic, and a nursery. It was managed by the IITA Genetic Resources Unit until 2011 when it was handed over to the 5-year Leventis-funded Forest Project which in 2014 put forward a proposal for restoration. The proposal was successful and the project began in March 2015 on receipt of funds.

The Arboretum occupies 5.87 ha. It is partly enclosed by a forest fragment 25.03 ha in extent which borders on a large pond in the northwest corner. At the start of the project the Arboretum had been abandoned for over a decade and was largely impenetrable. Many trees had died or fallen and the entire area was badly infested with invasive exotics, notably *Leucaena leucocephala*, which were introduced for alley cropping. The entire area is a haven for wildlife, notably the Straw-coloured Fruit Bat *Eidolon helvum* which at certain times of the year is present in spectacular numbers.



Figure 2: The IITA Arboretum and surrounding forest

Aims of the Tree Heritage Park project are: to establish an Arboretum of indigenous tree species, both as a living collection and as stored seeds in the IITA Genetic Resources Centre; provide resources for research, education, and propagation; create a focus for further funding of tree conservation in Nigeria; and to raise awareness that native trees are better adapted to local soils and climate, support wider biodiversity, and produce more diverse raw materials than exotics.

These aims are based on the fact that 80% of rainforests have been destroyed in Nigeria since 1990 and the deforestation rate is 3.5% (350,000 – 400,000 ha) a year. According to the Nigerian Conservation Foundation, forest cover is now to 4%. There is no internationally recognized Red List for Nigeria but it is assumed that this high rate of deforestation is leading to many species becoming scarce, locally and/or commercially extinct, and depleted genetically. To date, tree planting initiatives have mostly focused on exotics, such as teak, gmelina, and eucalyptus because there is little appreciation of the importance of native trees and almost no availability of planting material. In addition to raising awareness about threats to indigenous species, the project will encourage conservation partnerships and offer training, practical advice and materials for the restoration of degraded landscapes.

The first task was to ground-truth the entire area. Using the original Field Plan, which was available as hard copy only, each plot was located and marked using a concrete block painted with the plot number; these blocks will remain in situ until all restoration work is completed and there is new signage. When the boundaries of each plot were established, surviving trees were counted and compared with the number originally planted, as recorded on a master list. The only plots where all native trees survived were plot 121 *Erythrophleum suaveolens* (Guill. & Perr.) Brenan and plot 130 *Cola millenii* K. Schum. Surprisingly, the only indigenous savanna species in original plots, baobab *Adansonia digitata* Linn. and shea butter *Vitellaria paradoxa* Gaertn.f., had some survivors. Though uncharacteristically tall and slender, with few leaves and branches through overcrowding and a heavy burden of climbers, they rapidly put out new growth and should make a good recovery. Some plots had more trees than first planted due to regeneration by seedlings from the parent trees, notably plot 2 *Millettia aboensis* (Hook.f.) Bak., and plot 87 *Glyphaea brevis* (Spreng.) Monachino. A total of 41 plots had no survivors, possibly through overcrowding because plots were not thinned 10 years after planting as planned. In addition to these vacant plots, there were some that were never planted; all became densely occupied by *Leucaena leucocephala* which was first planted in plot 180.



Figure 3: Original hard copy field plan of the Arboretum with plots colour-coded for clearing or restoration

After ground-truthing, plots were assessed and colour-coded (see Fig. 3) for clearing or restoration. There were six categories: indigenous but common (blue); high priority indigenous species (orange); exotics which will be completely cleared (yellow); exotics which will be cleared after propagating for nursery stock (green); jackfruit *Artocarpus heterophyllus* Lam. which though exotic will be left as a source of food for wildlife and a good place to position a remote camera (pink); and unplanted (hatching on white for un-numbered plots and on yellow for numbered plots where species were designated but never planted).

Ground-truthing and assessment of plots were carried out in May and June 2015. The detailed surveys enabled staff to plan and carry out efficient collection of wildlings and other propagation material for the nursery from a total of 44 species. A maximum of 50 wildlings was collected of most species, both exotic and indigenous; in some cases fewer than 50 could be found and for a few species more than 50 were collected owing to rarity or popularity in terms of nursery sales. Clearing plots of exotics proved more difficult than anticipated. Felling certain trees at the front of the Arboretum risked damage to power lines and in a number of plots exotics had to be left rather than cause damage to important indigenous trees. The use of bulldozer or bucket loader proved impractical in situations which were too difficult for machine and operator so all clearing had to be done as teamwork with a hired chainsaw operator felling trees and cutting into logs and planks while staff and casuals use cutlasses (machetes) to chop branches for fuelwood and strip bark from stumps. This method of clearing was more time consuming and labour intensive but proved to give better control, cause less compaction and erosion, and was safer in difficult working conditions.

As progress was made with clearing both plots and roads, a new layout was developed to indicate proposed roads and trails, positions for infrastructure, and new plots. The original 180 plots have been largely abandoned in favour of larger plots that contain more than one species. This arrangement allows planting of understorey species and shade-demanding young trees with either faster growing light-demanding species or with existing mature trees.On 19 April 2016 a tree planting event was held to mark the start of planting in the new Tree Heritage Park. An Ijebu mahogany *Entandrophragma angolense* (Welw.) C.DC. VU was planted by Dr David Ladipo, Director, Centre for Environment, Renewable Natural Resources Management, Research & Development (CENRAD), who set up the IITA arboreta in Ibadan, Onne and Mbalmayo (Cameroon) in the 1990s. After planting the tree he spoke of the crisis facing Nigerian trees and forests which are over exploited and fast disappearing. Mahoganies (*Entandrophragma* spp.) are slow growing, taking over 35 years to flower for the first time, and mature specimens are now extremely rare due to the high demand for timber. All *Entandrophragma* species are now considered threatened and are on the IUCN Red List.

More species have been planted during the 2016 rainy season which are known to be decreasing or on the IUCN Red List, including:

- *Albizia ferruginea* (Guill. & Perr.) Benth VU*;*
- *Cola nigerica* Brenan & Keay CR;
- *Entandrophragma cylindricum* (Sprague) Sprague VU;
- *Entandrophragma utile* (Daw & Sprague) Sprague VU;

- *Irvingia wombolu* Vermoesen;
- *Khaya anthotheca* (Welw.) C.DC. VU;
- *Khaya senegalensis* (Desr.) A.Juss. VU*;*
- *Lovoa trichilioides* Harms VU;
- *Mansonia altissima* (A.Chev.) A.Chev.;
- *Milicia excelsa* (Welw.) C.C.Berg NT;
- *Nauclea diderrichii* (T.Wild & T.Durand) Merrill VU;
- *Pouteria alnifolia* (Baker) Roberty*;*
- *Pterocarpus osun* Craib*; and*
- *Terminalia ivorensis* (A. Chev.) VU.

The Forest Unit's second tree conservation project is funded by the Mohammed bin Zayed Species Conservation Fund from November 2015 to February 2017 and supports the Tree Heritage Park project, as indicated by the title "*Prioritising and protecting Nigeria's most threatened trees*: *conservation, propagation, and ex situ cultivation of endangered indigenous tree species".* In this project the Forest Unit is in-country partner while the lead partner is Botanic Gardens Conservation International (BGCI) www.bgci.org/where-we-work/nigeria Global Trees Campaign www.globaltrees.org/projects/prioritising-and-protecting-nigerias-threatened-trees. As a pilot project it focuses on southwestern Nigeria but is expected to have benefits outwith the immediate area and beyond borders as most target species occur widely in west and central Africa.

The project proposal dates back to a visit by the author to BGCI in Kew, London, following a BGCI study in 2012 that encouraged African botanic gardens and similar institutions to upload lists of the plants held in their collections to BGCI's PlantSearch database, and provide information on tree conservation and forest restoration projects. The study identified a lack of *ex situ* conservation collections of native trees in Nigeria or elsewhere. A recently funded scoping review of high priority countries for tree seed collection (BGCI, available on request), further identified Nigeria as a priority country in need of increased resources, capacity development and conservation action for threatened tree species.

The first task in developing a proposal was to compile a list of trees that in the opinion of experts in Nigerian trees and forests, both in-country and in international institutions, are in serious decline. The consultation resulted in a list of 55 species, of which four were selected as target species, reported in <5 *ex situ* collections globally, namely Nigerian kola *Cola nigerica* Brenan & Keay CR, cherry mahogany *Tieghemella heckelii* (A.Chev.) Pierre ex Dubard EN, sapele *Entandrophragma cylindricum* (Sprague) Sprague VU, and afrormosia *Pericopsis elata* (Harms) Van Meeuwen EN. The list is available from the author.

The overall aim of the project is to prevent further decline of the target species and at least eight others by establishing *ex situ* conservation of threatened trees at IITA Tree Heritage Park through seed and living collections. More specifically, the aims are to refine and if necessary expand the list of priority trees, highlight the need to scale up red listing and conservation action for Nigeria's trees at local, state, and federal level, and facilitate collaboration and capacity building among conservation partners by providing information and training.

There are about 935 tree species in Nigeria (Keay 1989). When the project started, 121 were assessed by the IUCN Red List as threatened - critically endangered (CR), endangered (EN), vulnerable (VU), or near threatened (NT). In August 2016 the list was updated following fieldwork carried out for the *Red Data Book of the Flowering Plants of Cameroon* (Onana & Cheek 2011), giving Red List status to 16 more species. All these species were already on the project's list of threatened trees.

The IUCN recommends updating assessments every five years. However, assessments of target species for this project were made before 2001 and were presumably based on populations in other countries as Nigeria currently has no national botanic garden or other institution that carries out Red List assessments. This is cause for concern, especially for species such as Senegal rosewood, *Pterocarpus erinaceus* Poir, which is in demand now that Asian rosewoods are commercially extinct. It is estimated by the Environmental Investigation Agency that 80% of Senegal rosewoods have been logged in Nigeria in the past two years for export to China.

As funding is very limited for this pilot project, the strategy is to develop five principal conservation partnerships where seed collecting and population assessments may be combined with capacity building and practical training. They are: Okomu National Park, Edo State; Omo Forest Reserve, Ogun State; Akure Forest Reserve and Federal University of Technology Akure, Ondo State; Ekiti State Department of Forestry, Ekiti State University, and Ekiti State Tree Growers Association, Ekiti State; Ekuri community and Cross River Forestry Commission, Cross River State.



Figure 4: Map of Nigeria to show locations of collecting areas and conservation partners

These connections were strengthened and new partnerships developed at a Tree Conservation workshop held at IITA from 21 to 23 June 2016 which was attended by 33 participants from many different organisations and institutions with interests in trees and forests. In addition to Forest Unit staff, contributors to the workshop included: Kirsty Shaw, Head of Ecological Restoration and Tree Conservation, BGCI Global Trees Campaign, UK; Adam Harrower, Senior Botanical Horticulturist, Kirstenbosch Botanic Garden, South Africa; and Dr Emmanuel Aigbokhan, Associate Professor, Department of Plant Sciences and Biotechnology, University of Benin.

A highlight of the workshop was a field visit to the Tree Heritage Park project where participants planted 21 African black walnut *Mansonia altissima* (A. Chev.) A. Chev. EN and 12 sapele *Entandrophragma cylindricum* (Sprague) Sprague VU. These seedlings were among priority species donated to the project by attendees. Others included: dry zone mahogany *Khaya senegalensis* (Desr.) A. Juss. VU; white mahogany *Khaya anthotheca* (Welw.) C.DC. VU; and black afara *Terminalia ivorensis* A. Chev. VU. Donations such as these are valuable contributions to the project as each accession adds genetic diversity.



Figure 5: Tree Conservation workshop: Participants plant endangered African black walnut *Mansonia altissima* in the IITA Tree Heritage Park. Photo: D. Bown.

In addition to planting threatened trees in the Tree Heritage Park, the project also stores seeds in the IITA genebank (Genetic Resources Centre) for research and reforestation projects. To date seeds of the following species have been stored: *Afzelia africana* VU; *Afzelia bella; Albizia bipindensis* VU; *Entandrophragma angolense* VU; *Pterocarpus osun;* and *Terminalia ivorensis* VU. Subject to availability of funding, plans for continuation of the pilot project include re-modelling of the Forest Project website www.reforest-iita.org and production of a an affordable and accessible Manual of Tree Propagation which is downloadable page by page or in its entirety as either soft copy or for printing and insertion into an A4 file.

REFERENCES

Aigbokhan, E. I. (2014). Annotated Checklist of Vascular Plants of Southern Nigeria – a quick reference guide to the *Vascular Plants of Southern Nigeria*: a systematic approach. Uniben Press, Benin City, 346 pp.

Borokini, T. I. A Systematic Compilation of IUCN Red-listed Threatened Plant Species in Nigeria. *International Journal of Environmental Sciences* Vol. 3. 2014, pp. 104-133.

Bown, D. (2013). Common Plants of IITA. International Institute of Tropical Agriculture (IITA), 136 pp.

Elliott, S., Blakesley, D., Hardwick, K. (2013). Restoring Tropical Forests. Kew Publishing, 344 pp.

Hawthorne, W., Jongkind, C. (2006). Woody plants of Western African forests: A guide to the forest trees, shrubs and lianes from Senegal to Ghana. Royal Botanical Garden, Kew, 1023 pp.

Hutchinson, J., Dalziel, J.M. (1963) Flora of West Tropical Africa. Crown Agents, London, 6 vols.

Keay, R.W.J., Onochie, C.F.A., Stanfield, D.P. (1964). Nigerian Trees. Federal Department of Forest Research, Ibadan, 2 vols.

Keay, R.W.J. (1989). Trees of Nigeria. Clarendon Press Oxford, 476 pp.

Lemmons, R.H.M.J., Louppe, D., Oteng-Amoako A.A. (editors). (2008). Plant Resources of Tropical Africa 7 (2). Timbers 2. PROTA Foundation, Wageninen, Netherlands / Backhuys Publishers, Leiden, Netherlands / CTA, Wageninen, Netherlands. 704 pp.

Louppe, D., Oteng-Amoako, A.A., Brink, M. (editors). (2008). Plant resources of Tropical Africa 7 (1). Timbers 1. PROTA Foundation, Wageninen, Netherlands / Backhuys Publishers, Leiden, Netherlands / CTA, Wageninen, Netherlands. 704pp.

Moorman, F.R., Lal, R., Juo, A.S.R. (1974). The Soils of IITA. IITA Technical Bullet 3.

Neuenschwander,P., Sinsin, B., Goergen, G. (editors) (2011). Nature Conservation in West Africa: Red List for Benin. IITA, Ibadan, Nigeria, 365 pp.

Neuenschwander, P., Bown, D., Hèdégbètan G.C., Adomou, A. (2015) Long-term conservation and rehabilitation of threatened rain forest patches under different human population pressures in West Africa. Nature Conservation 13: 21-46.

Okon, E., Bown, D., Isichei, A. (editors) (2013). Nigerian Forests-Protection and Sustainable Development. Joseph Ayo Babalolo University, 320 pp.

Onana, J.M., Cheek, M. (2011). Red Data Book of the Flowering Plants of Cameroon: IUCN Global Assessments. Kew Publishing, 578 pp.

Poorter, L., Bongers, F., Kouamé, F.N., Hawthorne, W.D. (editors) (2004). Biodiversity of West African forests: An ecological atlas of woody plants species. CABI Publishing, Cambridge, USA, 521 pp.

A Matrix Model for Predicting the Number of Forestry Graduates Produced in the University of Ibadan, Nigeria

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ABSTRACT

A matrix model was constructed and used to predict the number of forestry graduates produced in the Department of Forest Resources Management, University of Ibadan, Nigeria. The matrix represented the progression of a student based on the academic performance from the year of admission to the final year. A study period of 5 years was used for the model calibration. The model predicted that the probability of a student's graduation increased as the student moved from a lower level to a higher level. Conversely, results showed that the probability of non-graduating decreased from lower level to higher level. A prediction error rate of 5% was obtained.

Keywords: Transition matrix, markov chain, stochastic process

INTRODUCTION

Forests constitute one of the major renewable natural resources of mankind (FAO, 1985). The sustainable management of the Nigerian forests requires a high quality of manpower. In order to provide a high level of qualified professionals in forestry, the Federal Government of Nigeria and United Nations Development Programme (UNDP) provided the required fund for the establishment of the Department of Forestry, University of Ibadan, Nigeria (now Department of Forest Resources Management) in 1963 while Food and Agriculture Organisation (FAO) of the United Nations diligently served as the implementing agency. In this paper, a matrix model will be developed and will be used to predict the number of forestry graduates that can be produced in the Department of Forest Resources Management of the University of Ibadan over a specified period of time.

METHODS

Data Collection

The resource data for the study came from the records of the academic performances of students that were admitted to the Department of Forest Resources Management under a five-year degree programme. The academic record of each student was evaluated from the year of entry (100 Level) through the graduating class (500 Level).

Projection Matrix Structure

The movement of a student from 100 level to a higher level would be represented in terms of a **Canonical form** of Markov Chains (Bartholomew, 1972). It is conventional to order the States such that all those that are associated with closed classes are entered first and then followed by those associated with transient classes.
The process of graduating a student can be considered to have seven states. The seven states are represented thus:

W = Student can be asked to withdraw due to poor academic performance as set by University Ibadan Senate
G = Student can graduate after moving from 100 level to 500 level
1 = Student in 100 level (100L)
2 = Student in 200 level (200L)
3 = Student in 300 level (300L)
4 = Student in 400 level (400L)
5 = Student in 500 level (500L)
The states W and G are absorbing states such that once a student enters any of them, there are no possible transitions to the states (1, 2, 3, 4 and 5).

The states (1, 2, 3, 4 and 5) are transient states. This is the situation as students engage themselves in academic activities to move to the graduating class. The transition matrix **P** in Canonical form ((Bartholomew, 1972; Chung, 1960); Cox and Miller, 1965) is as follows:

P =		W	G	1	2	3	4	5
	W	1	0	0	0	0	0	0
	G	0	1	0	0	0	0	0
	1	p	0	Q	R	0	0	0
	2	p	0	0	Q	r	0	0
	3	p	0	0	0	q	R	0
	4	p	0	0	0	0	Q	r
	5	p	r	0	0	0	0	q

Canonical Form:

$$\boldsymbol{P} = \begin{bmatrix} \underline{P_i} & \underline{O} \\ \underline{R} & \underline{Q} \end{bmatrix} \quad (1)$$

Where:

$$\underline{\boldsymbol{P_i}} = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} \quad (2)$$

$$\mathbf{O} = \begin{vmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{vmatrix} \quad (3)$$

$$\mathbf{R} = \begin{vmatrix} P & 0 \\ P & 0 \\ P & 0 \\ P & 0 \\ P & R \end{vmatrix} \quad (4)$$

$$\mathbf{Q} = \begin{vmatrix} Q & R & 0 & 0 & 0 \\ 0 & Q & r & 0 & 0 \\ 0 & 0 & q & R & 0 \\ 0 & 0 & 0 & Q & R \\ 0 & 0 & 0 & 0 & Q \end{vmatrix} \quad (5)$$

There are restrictions in the transition of students during the study period:

1. A Student is allowed to move only to the next level during the beginning of the academic session.
2. No student is allowed to move backwards.

The process can be represented diagrammatically by Figure 1.

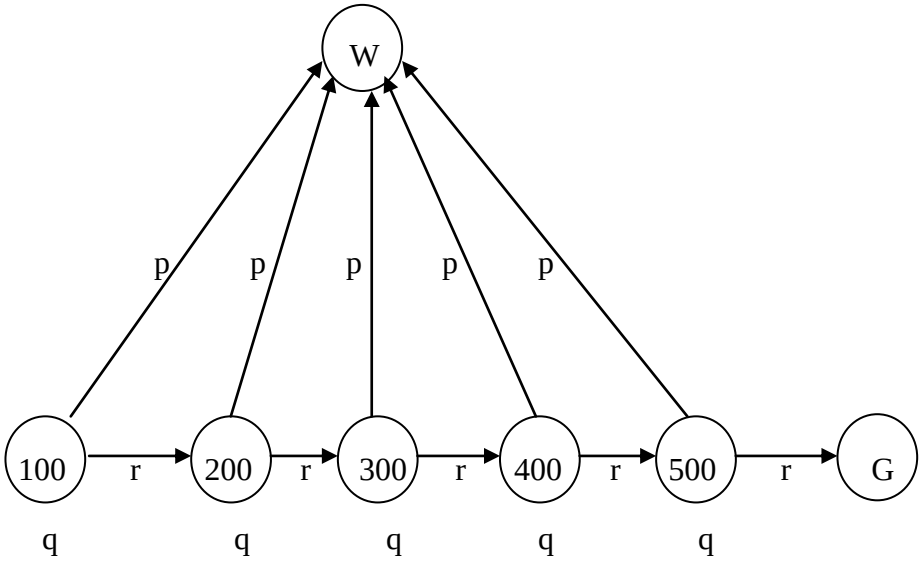


Figure 1: The promotion chain line

Where: r = Probability of moving from i to j in one academic year, j = i + 1

p = Probability of withdrawal i.e. move from states (100L – 500L) to withdrawal (W)

q = Probability of repeating a class

such that: p + q + r = 1

The sub-stochastic matrix **Q** determines the progression of students in the transient states of 100L-500L.

2.3 *Fundamental Matrix* (*M*)

$$\underline{\boldsymbol{M}} = [\boldsymbol{I} - \boldsymbol{Q}]^{-1} \quad (6)$$

$$\underline{\boldsymbol{B}} = \boldsymbol{MR} \quad (7)$$

Where the element $\{b_{ij}\}$ is the probability that if a student starts in transient state S_i (i = 1,…,5) it will enter into either of the closed states {W, G} i.e. the student will either graduate or will be asked to withdraw.

The probability that a student will eventually graduate starting from 100L is the first element of the second column of $\underline{\mathbf{B}}$. Similarly, the probability that a student will be asked to withdraw starting from 100L is the first element of the first column of $\underline{\mathbf{B}}$ i.e. $\{b_{11}\}$.

If we therefore know the number of students admitted to 100L say (N), the number of projected graduates that will graduate is given by:

$$N_G = \{b_{12}\}N \tag{8}$$

Similarly, the projected number of non-graduating students will be given by:

$$N_w = \{b_{11}\}N \tag{9}$$

2.4 *Construction of Fundamental Matrix*

$$\underline{\boldsymbol{M}} = [\boldsymbol{I} - \boldsymbol{Q}]^{-1} \tag{10}$$

Where **I** is the identity matrix and **Q** is as shown in the Canonical form of the transition matrix **P**. The inverse of **M** exists and is positive (Guilband, 1977; Osho, 1991, 1996)

In the academic year of 2010/2011, forty-four (44) students were admitted to 100L of the Department of Forest Resources Management, University of Ibadan. The academic performances were monitored over a study period of 5 years. In the 2014/2015, thirty-four (34) students graduated, eight (8) failed and two (2) students were classified as withdrawal list.

Estimates of p, q and r were obtained as:

$$r = {}^{34}/_{44} = 0.77 \tag{11}$$

$$p = {}^{2}/_{44} = 0.05 \tag{12}$$

$$q = \left[1 - \frac{(36)}{44}\right] = 0.18 \tag{13}$$

From these estimates, we obtained the fundamental matrix **M.**

$$\mathbf{M} = \begin{vmatrix} 0.82 & -0.77 & 0 & 0 & 0 \\ 0 & 0.82 & -0.77 & 0 & 0 \\ 0 & 0 & 0.82 & -0.77 & 0 \\ 0 & 0 & 0 & 0.82 & -0.77 \\ 0 & 0 & 0 & 0 & 0.82 \end{vmatrix} \tag{14}$$

RESULTS

Prediction with the Model

$$\underline{\mathbf{B}} = \mathbf{MR}$$

Where: matrix **R** is defined as:

$$\mathbf{R} = \begin{vmatrix} 0.05 & 0 \\ 0.05 & 0 \\ 0.05 & 0 \\ 0.05 & 0 \\ 0.05 & 0.77 \end{vmatrix} \quad (15)$$

Matrix **B** is therefore given by:

$$\mathbf{B} = \begin{vmatrix} 0.270 & 0.730 \\ 0.222 & 0.778 \\ 0.172 & 0.828 \\ 0.118 & 0.882 \\ 0.061 & 0.939 \end{vmatrix} \quad (16)$$

The elements of the first row of $\underline{\mathbf{B}}$ i.e. $\{b_{11}, b_{12}\}$ are of paramount importance (Lawles and Moleish, 1984).

b_{11} = Probability that a student who commences the degree programme from 100L would not graduate ($b_{11} = 0.270$)

b_{12} = Probability that a student who commenced the degree programme from 100L would graduate ($b_{12} = 0.730$)

$N_G = b_{12} \times N = 0.730 \times 44 \approx 32$

$N_W = b_{11} \times N = 0.270 \times 44 \approx 12$

Where: N_G = Projected number of students that graduated

N_W = Projected number of students that are non-graduating

N = Number of students admitted into 100 Level (44).

DISCUSSION

The model was validated with the academic records of the forty (40) students who were admitted in the 2009/2010 session into the Department of Forest Resources Management, University of Ibadan. The projected number of graduating students was twenty-nine (29), while the number of non-graduating students was estimated as eleven (11). The actual number of students that graduated was twenty-seven (27) and the number of non-graduating students was thirteen (13). The error rate in the prediction was 5%. This level of precision will appear to be acceptable.

CONCLUSION

The need to train forestry professionals for the development and efficient uses of the vast forest resources in Nigeria is compelling.

Presently, forest management in Nigeria is extensive due to inadequate and well-trained manpower. May be, when we are able to produce a well-trained manpower, we will be able to manage our forests sustainably. The application of the model can help achieve this highly desirable objective.

REFERENCES

Bailey, N.T.J. (1964): The elements of stochastic processes with application to the Natural Sciences, Wiley

Bartholomew, D.J. (1972): Stochastic models for Social Science, Wiley

Chung, K.L. (1960): Markov chains with stationery transition probabilities. Springer-Veries, Berlin

Cox, D.R. and Miller (1965): Theory of stochastic processes, Methuen, London.

FAO (1985): The disappearance of the Tropical Forests of Africa, 148:18-30

Gruilband, O. (1977): Estimating the probability eigenvector and related characteristics of ergodic transition matrix. *Scan J. Stat.* 4:97-104

Lawles, J.B. and Moleish, D.C. (1984): The information in aggregate data for Markov chains. *Biometrika*, 7(3)

Osho, J.S.A. (1991): Matrix model for tree population projection in a Tropical Forest of South Western Nigeria. *Ecological Modelling*, 59:247-255

Osho, J.S.A. (1996): Modelling the tree population dynamics of the most abundant species in Nigerian Tropical Rainforest. *Ecological Modelling*, 85: 175-181.

Dwindling Forest Cover in Nigeria: A Tragedy for Forestry Development

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ABSTRACT

Forestry is a unique sector in the Nigerian economy owing to its peculiar responsibilities in the conservation, management and sale of forest produce, and because of the concomitant necessity for its long-range planning. However, the state governments in Nigeria have since the independence in Nigeria jettisoned the objectives of forest reservation in perpetuity and replenishment programme. The study therefore, reviewed and examined the trend of past Forestry Act in Nigeria; examined the current forest cover using forest cover from 2001 to 2014 and number of persons per ha of forest cover in Nigeria with a view to drawing the attention of the federal and State Governments to status of forest cover as well as immediate danger of de-reservation of forest estate in Nigeria. The result indicated that after the colonial administration in Nigeria, the forest estate has been diminishing at an unprecedented rate with every successive government in Nigeria. The Federal Government as a federated country has no forest estate of its own. It was revealed that Nigeria lost 378,680 hectares in all the 36 states and the Federal Capital Territory in 14 years (2001-21014). *The ratio of remaining forest cover in Nigeria per person was 0.004ha:1person as at 2014. In the six geopolitical zones of Nigeria, namely:South-East; South-South; South-West; North-Central; North-East; and North-West, the ratios of remaining forest cover per person were 0.031ha:1person; 0.046ha:1person; 0.103ha:1person; 0.016ha:1 person; 0.11ha: 1person; and 0.00013ha:1 person, respectively.*
The dwindling forest cover in Nigeria is inimical to forestry development and its consequences pose serious danger to Nigerian environment in the immediate future. It is recommended that the Federal Ministry of Environment, Federal Department of Forestry, States Forestry Services, Nigerian Universities where forestry is taught and other forestry stakeholders should of necessityhave a national summit to address the intractable problems militating against forestry sector in Nigeria.

Keywords: Forest cover, forest reservation, forest act, forest policy, dwindling forest estate

INTRODUCTION

Forestry is a unique sector in the Nigerian economy owing to its peculiar responsibilities in the conservation, management and sale of forest produce, and because of the concomitant necessity for its long-range planning. The forest is an economic resource and the purpose of its development is enhancement of living standards and welfare of the people (Adeyoju, 1978).

Forestry practice in Nigeria began in 1887 (Adeyoju, 1975). Several legislations were passed and aimed at consolidation, reservation, conservation and management of the nation's forest resources. One method of ensuring and regulating the role of forestry in the national economy is creation of forest reserves. The colonial administration established forest reserves in every ecological zone of Nigeria. These forest reserves were established between 1902 and 1940 in tracts of land with relatively low human population and with no cumbersome claims. Some of the forest reserves were needed for socioeconomic reasons, particularly in the Eastern part of Nigeria (Rosevear, 1953). On attainment of political independence in 1960, about 10% of the land area of Nigeria was constituted forest estate each with its own gazette notice, constitution, boundary descriptions, beacons and survey maps signed by the regional surveyor-general (Adeyoju, 1975). Nevertheless, the perception of forestry development in Nigeria has changed over time. It initially consisted of acquisition of sustainable forest areas, constitution of forest reserves and consolidation of the forest estate. Subsequent development efforts involved introduction of various bills, rules, proclamations and ordinances aimed at enhancing forestry administration in the country. Further development involved the exploitation and marketing of forest products as well as forest renewal based on the adoption of various silvicultural techniques.

Nigeria has made several attempts at putting in place programmes that would ensure the efficient management of her forest resources. These include the establishment of Industrial Plantations from 1978, Land Use and Vegetation survey between 1975 and 1978, Production of perspective plan for the period 1990-2005 and formulation of a Nigerian Forestry Action Programme (NFAP) in 1997. However, most of these initiatives have had limited impact in turning around the precarious state of the forest estate (FDF, 2000). The

NFAP, one of the recent National Forest Programmes in Nigeria, has evolved through articulated planning and involvement of all stakeholders in the forestry sector. Unfortunately, the NFAP did not proceed to implementation phase. The situation of Nigerian forest has dramatically changed 56 years ago after independence. The prescriptions for forest allocation have been wholly ignored, while the working plans, perimeter beacons and boundary cleaning operations have been abandoned. In addition, the state forest departments have been unable to curtail the spate of requests from corporate and influential individuals for excision from forest estate of land for establishment of cocoa, oil palm, rubber and fruit plantations. The unfortunate impression has thus been created that the forest estate exists as a land bank for other sectors. Although, the post-independence period witnessed a few gains in forestland, there has been a continuing demand for de-reservation (Agbeja, 2004).

Nigeria lacked coherent National Forest Policy until 2006 when National Forest Policy was enunciated and approved (Federal Ministry of Environment, 2006). Till date, the National Forestry Act has not been approved in the National Assembly. As a result of population pressure, the acceptable limits to the rate of forest exploitation are being breached and in many cases, the tenets of good forest management are disregarded. Problems associated with ownership issue, forest policy, forestry act, investment strategies, revenue generation, governance and capacity development have seriously affected the Nigerian forestry sector. The state governments in Nigeria are empowered to manage the forest estate as they deem fit. Most of the forest lands are regarded as public property that lacks investment potential. The Nigerian forest estate is small and is under single management. According to Federal Ministry of Environment, Abuja (2006), the total forest reserves in Nigeria is 96,043km^2 or about 10 million hectares, which is about 10 percent of Nigeria's land area of 923,767km^2. The total forest plantation in Nigeria is estimated at 269,000ha. However, FAO (2001) stated that within 10 years (1990-2000), the area change of total forest in Nigeria was -398,000 hectares per year (-2.6%).This was also corroborated by UNEP (2006) that Nigeria and Cote d'Ivoire have by far the highest annual rate of forest loss, as nearly as 663,000ha. This rate was inimical to Sustainable Forest Management in Nigeria. The outcomes of these negative changes are attributable to discretionary power of government to de-reserve or harvest the forest; lack of National Forestry Act; the prevalence of illegal logging; epileptic funding of forestry programmes under state basis; and ill-equipped forestry institutions to foster sustainability and to implement forestry objectives.

Nigeria is a federated country. The question is now posed. ***Is it justifiable to enact National Forestry Act when the Federal Government has no forest estate of its own?***

From the above introduction, the paper therefore, reviewed and examined the trend of past Forestry Act in Nigeria; examined the current forest cover and number of persons per ha of forest cover with a view to drawing attention of the federal and State Governments to forestry development as well as immediate danger of de-reservation of forest estate in Nigeria.

METHODOLOGY

Study Area

Nigeria, officially the Federal Republic of Nigeria is situated in the Western part of Africa. Its coastal boundary is delimited by the Gulf of Guinea in the south and the land boundary is shared by Cameroon and Chad in the east, Niger in the north and Benin in the west. Abuja is Nigeria's capital city. Nigeria covers a total area of 923,768 km^2 making it the thirty second largest country of the world. It has a small coastline of 853 km in comparison to its total land boundary of 4047 km. The latitudinal and longitudinal extent of the country is 4° to 14°N and 2° to 15°E respectively (Figure 1). The population of Nigeria in year 2006 was 140,003,542. The number of males was 71,709,859 while that of females was 68,293,683.
(http://www.nigeriamasterweb.com/Nigeria06CensusFigs.html). In year 2016, the population of Nigeria with an annual growth rate of 2.5% is estimated as 187,945,282.

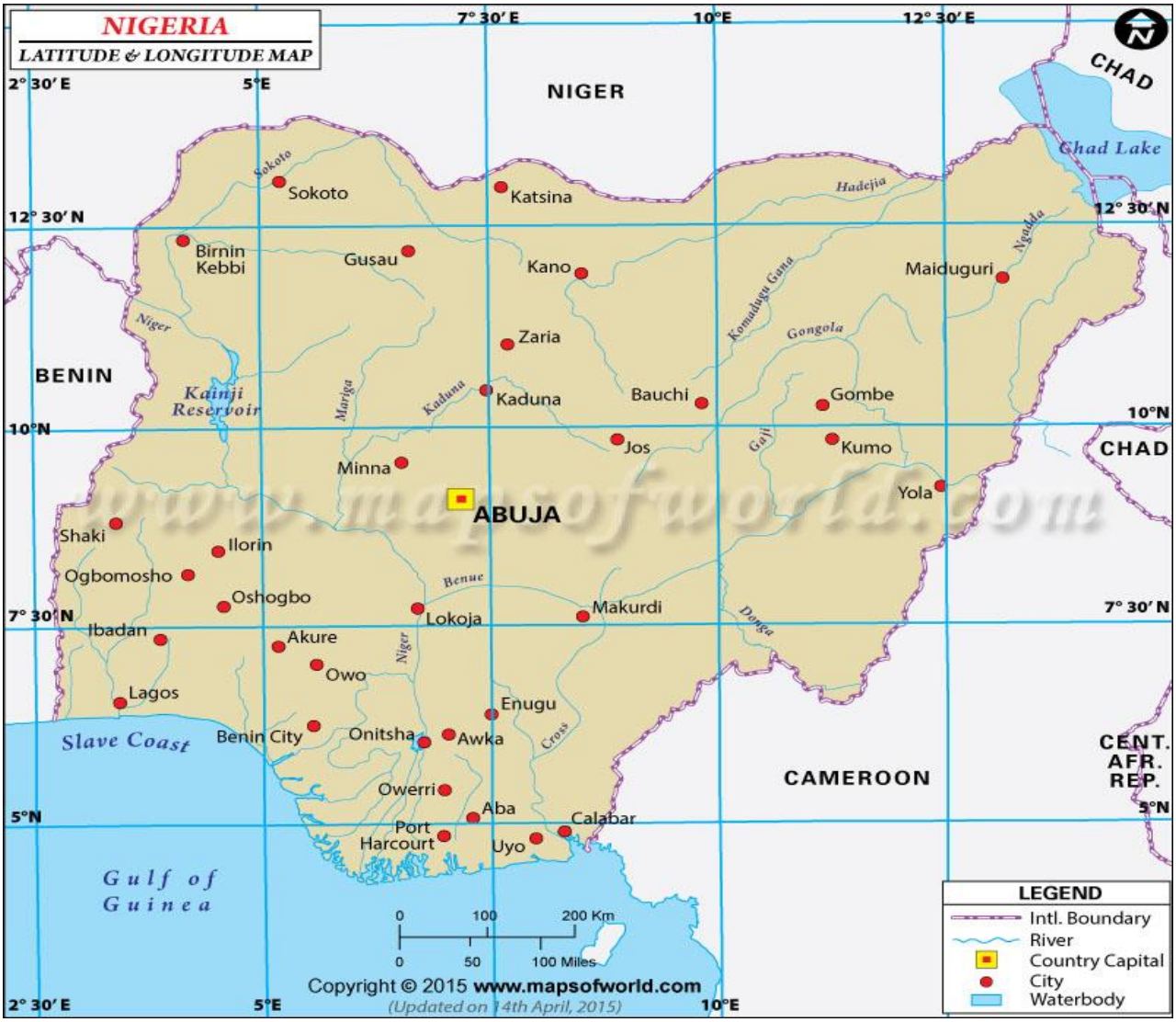


Figure 1: Map of Nigeria showing Longitudes and Latitudes

Data Collection and Analysis

Data collection for this study were from secondary sources which include journals, technical reports, textbooks and internet.

RESULTS AND DISCUSSION

Review of Forestry Act in Nigeria

Forestry practice began in 1887 (Adeyoju, 1975). Several legislations were passed and aimed at consolidation, reservation, conservation and management of the nation's forest resources, including:

- The Forestry Proclamations No. 28 of 1901. This provided for the management and exploitation of mahoganies and wild rubber (funtumia).
- The Timber Rule of 1906, which compelled loggers to plant a number of seedlings to replace a felled tree.
- The Forestry Act of 1908, which provided for the constitution of forest reserves with provisions for the recognition of usufruct rights of local communities or indigenous land owner(s).

- The Forest ordinance of 1919 unified the forestry departments in all parts of Nigeria following the amalgamation of northern and southern protectorates in 1914. The ordinance further expanded the regulatory measures on the control of forestry exploitation
- The Forest (Amendment) Ordinance 1927 gave legal backing to the constitution of native authorities' forest reserves, which are still found in some of the northern states.
- The first comprehensive law for nationwide preservation and control of forestry was promulgated in 1938 as the Forestry Act 1938 and was in force throughout the country. This act was further consolidated or amended in 1958.

The actual devolution of responsibility over forestry matters from the Federal Government to other tiers of government took its root from 1954 Nigeria Order in Council when Nigeria became a Federation with the emergence of regional governments. Each region subsequently adopted the Forestry Act 1958, with consequential amendments over the years to suit the emerging geopolitical and constitutional arrangements as well as to address contemporary forestry issues from time to time. However, many substantial provisions dealing with reservation, protection, conservation and management of the forest resources have remained virtually the same over the years, based on the principles of sustained yield management.

Under the federal constitution, the regional governments had responsibility for forest administration. At the inception of the federal institution in 1954, the federal government gave responsibility to forestry research department, while the regional governments were empowered to manage the forest estate as they deem fit. Consequently, regional forest policies were enunciated. Regional forest policy objectives were designed without reference to the condition and economic development of contiguous regions. Indeed, in the early days of the federation, each region gathered its own constitutional rights jealously and without reference to the consequence of such decisions to the neighbouring regions. It was only shortly before independence in 1960, an arrangement whereby some level of professional consultation could be effected between regional forest services was instituted. Thus, a Forestry Technical Committee was established in 1958 with the Director of Forestry Research Department as chairman and all the Regional Chief Conservators (now Directors of Forestry in States) were the members. Even then, the functions of forestry technical committee were nebulous and the decisions were not bidden on the regions as such.

However, under the first military administration, the weakness of regional administration of natural resources became apparent and Forestry Act of 1958 was abolished. Consequently, the Federal Ministry of Agriculture was instituted in 1968 and also Federal Department of Forestry was instituted in 1970. The functions of the Federal Department of Forestry were to co-ordinate the work of State Forest Services, liaise with international forestry organization and assist State Forestry Services in providing funds both from federal sources and international financing institution for the development of forestry. However, the crop of the matters/problems that pertained to the ownership of forest land was and is still untouched. Subsequently, the National Forestry Development Committee and National Wildlife Conservation Committee were instituted under the chairmanship of the Director of Federal Department of Forestry. The membership of the two committees included Chief Conservators of each state. The Director of Forestry Research of Nigeria (FRIN), the head of Department of Forestry, University of Ibadan and other heads of new Universities and Directors of other related research institutes. The meetings of the two committees used to take place twice in a year and their recommendations were passed to National Council of Agriculture. As it so happens, the decisions of these two committees were far more mandatory during military administration than in the case of civilian regime era.

Nigeria has 36 states and Federal Capital Territory. Under Nigerian Constitution, forestry is a state subject i.e. the various state governments own and manage the forest estate. Consequently, each state government enunciates its own policy and state policy only caters for the limited view point foreseen by each state government. Over the last 50 years, there has been a great deal of disparity in the quality of forest policy, forest management and forest administration of Nigerian forests. This is as a result of the constitution of Nigeria which empowers each State to manage the forest reserves as it deems fit without ecological consequences of the neighbouring states. In a situation of unrelated state forest policies, there is therefore, a problem of confusion, duplication of efforts and uncoordinated forestry development strategy in Nigeria. Ideally, federal government ought to enunciate the national forest policy from which state governments can develop programmes of actions bearing in mind the ecological potential of the state concerned. The National Forest Policy of 2006 is explicit enough for accelerated forestry development in Nigeria (Federal Ministry of Environment, 2006). However, the Federal Government as a federated country has no forest estate of its own. Therefore, it is not justifiable to have Forestry Act in Nigeria. This is a tragedy for forestry development in Nigeria! However, other federated countries in the world have forest estates with corresponding National Forestry Act. The federal government has the responsibility to see to adequate forest estate in the country to enable the citizen to obtain the goods and services as and when needed. Consequently, federal government is the authority to institute national forest policy in other words, state forest policies are anachronistic.

Forest Cover in Nigeria

Nigeria was blessed with pristine forests till 1960. However, after independence in 1960, the forest cover began to diminish as a result of abolition of regional government in 1958 as well as geometrical increase in population. In the 1970s, when states were created, the

constitution of Nigeria empowered each state to manage her forest reserves as it deemed fit without even the ecological consequences to the adjoining states. It is disheartening that a federated country like Nigeria will be losing an unprecedented forest cover on an annual basis without Government intervention. However, it is not surprising because some State governments still believe that what God endows their states with like forests when removed, it would be naturally replenished without human efforts. A total forest gain (reserved and non-reserved forest) in Nigeria (Table 1) from 2001 to 2014 was 60,301 hectares while the total forest loss was 438,981 hectares. The implication was that Nigeria lost 378,680 hectares in all the 36 states and Federal Capital Territory in 11 years. Nevertheless, in a situation of inconsistent and inappropriate forest policies in various states in Nigeria coupled with lack of Federal Government Forest Estate, the country will continue to have serious de-reservation. This study is corroborated by the reports that objectives laid down in the recommended policies for forestry in Nigeria are thwarted by successive governments in the states as well as haphazardly implemented (Agbeja and Verinnumbe, 2006; Faleyimu, *et al.* 2008).

Forest cover per person in Nigeria

Table 2 (2.1. to 2.8) showed that the total population of Nigeria as at year 2006 was 140,003,542 comprising 71,709,859 males and 68,293,683. The estimated population of Nigeria based on 2.5% annual growth rate in 2016 was 187,945,282. The total forest cover in year 2000 was 89,501,693ha. Therefore, if total forest gain and forest loss are considered, the remaining forest cover in (both reserved and non-reserve forests) would be 89,123,013. The forest cover per person is ratio 0.04ha to 1 person. The implication is that Nigerian Forest cover had seriously diminished in the last 14 years (2001-2014).

Forest Cover per person in Six Geopolitical Zones of Nigeria

In the **South-East Geopolitical Zone** of Nigeria comprising Abia, Anambra, Ebonyi, Enugu and Imo States with a total population of 16,381,729 has 505,862ha of forest cover. The implication is that the forest cover(ha) per person is **ratio 0.031ha to 1 person.**

In the **South-South Geopolitical Zone** of Nigeria comprising Akwa-Ibom, Bayelsa, Cross River, Delta, Edo and Rivers States with a poplation of 21,014,655 has 967,096ha of forest cover. The implication is that the forest cover per person is **ratio 0.046ha to 1person**.

In the **South-West Geopolitical Zone** of Nigeria comprising Ekiti, Lagos, Ogun, Ondo, Osun and Oyo States with a population of 27,511,992 has 2,835,600 ha of forest cover. The implication is that the forest cover per person is **ratio 0.103ha to 1 person.**

In the **North-Central Geopolitical Zone** of Nigeria comprising Benue, Kogi, Kwara, Nassarawa, Niger and Plateau States with a population of 18,841,056 has 309,287 ha of forest cover. The implication is that the forest cover per person is **ratio 0.016ha to 1 person.**

In the **North-East Geopolitical Zone** of Nigeria comprising Adamawa, Bauchi, Borno, Gombe, Taraba and Yobe States with a poupulation of 18,971,965 has 2,055,842 ha of forest cover. The implication is that the forest cover is **ratio 0.108ha to 1 person.**

In the **North-West Geopolitical Zone** of Nigeria comprising Jigawa, Kaduna, Kano, Katsina. Kebbi, Sokoto and Zamfara States with a poupulation of 35,786,944 has 4,779ha of forest cover. The implication is that the forest cover is **ratio 0.00013ha to 1 person.**

The above ratio of forest cover per person in each geopolitical zone in Nigeria is corroborated by FAO (2001) that forest resources in most West African countries had dwindled. Nigeria had a total of forest area of 13,517,000ha (14.8% of the total land area) whose ha/capita was 0.1. The total area change between 1990 and 2000 was -398,000ha/year (-2.6%).

Table 1: Forest Cover from 2001-2014 in Nigeria

S/N	State	Land Area (Ha)	Forest Cover in 2000 (ha)	% Forest Cover in 2000	Tree Cover Loss (2001-2014)	Tree Cover Gain (2001-2014)
1	Abia	472226	113000	24	8602	1064
2	Adamawa	3401093	99,000	3	972	136
3	Akwa-Ibom	667419	121000	18	5235	737
4	Anambra	453138	34000	7	675	53
5	Bauchi	4903058	895	0	4	9
6	Bayelsa	944940	82300	87	8907	913
7	Benue	3118602	56000	2	562	24
8	Borno	6607588	1	3	1	0
9	Cross River	2094534	1,000,000	60	37869	4965
10	Delta	1625818	987	61	29209	7286
11	Ebonyi	618646	15000	2	1004	130
12	Edo	1956740	1000000	53	121311	30403
13	Ekiti	523021	403000	77	8220	176
14	Enugu	770092	63000	8	1153	19
15	Gombe	1798939	1	0	1	8
16	Imo	530389	101000	19	10697	941
17	Jigawa	2396817	3	0	0	0
18	Kaduna	4419400	5000	0	240	11
19	Kano	1982358	2	0	0	0
20	Katsina	2364473	2	0	9	0
21	Kebbi	3531054	166	0	160	0
22	Kogi	2873052	257000	9	16397	221
23	Kwara	3534147	105	3	9838	47
24	Lagos	308003	69000	23	4177	370
25	Nassarawa	2621138	12000	0	2376	31
26	Niger	6966616	15000	0	9987	69
27	Ogun	1603939	482000	30	36155	4257
28	Ondo	1447729	1000000	71	42061	4621
29	Osun	917464	696000	76	11998	200
30	Oyo	2734793	295000	11	16647	234
31	Plateau	2755650	8000	0	86	36
32	Rivers	834731	395000	47	7647	1516
33	Sokoto	3162145	4	0	4	0
34	Taraba	5975340	2000000	26	45042	1810
35	Yobe	4553076	26	0	24	0
36	Zamfara	3448834	32	0	28	0
	FCT	584691	16	2	1683	14
TOTAL	**Nigeria**	**89,501,693**	8,323,540	722	438,981	60,301

Source: http://www.globalforestwatch.org/country/NGA/1-37 (Accessed 02 September, 2016)

Table 2: Nigeria 2006 Census Figures

Table 2.1: South-East Geo-Political Zone

State	Male	Female	Total	% of the Nation
Abia	1,434,193	1,399,806	2,833,999	2.02
Anambra	2,174,641	2,007,391	4,182,032	2.99
Ebonyi	1,040,984	1,132,517	2,173,501	1.55
Enugu	1,624,202	1,633,096	3,257,298	2.33
Imo	2,032,286	1,902,613	3,934,899	2.81
Sub-Total	**8,306,306**	**8,075,423**	**16,381,729**	**11.70**

Table 2.2: South-South Geo-Political Zone

State	Male	Female	Total	% of the Nation
Akwa-Ibom	2,044,510	1,875,698	3,920,208	2.80
Bayelsa	902,648	800,710	1,703,358	1.22
Cross River	1,492,465	1,396,501	2,888,966	2.06
Delta	2,074,306	2,024,085	4,098,391	2.93
Edo	1,640,461	1,577,871	3,218,332	2.30
Rivers	2,710,665	2,474,735	5,185,400	3.70
Sub-Total	**10,865,055**	**10,149,600**	**21,014,655**	**15.01**

Table 2.3: South-West Geo-Political Zone

State	Male	Female	Total	% of the Nation
Ekiti	1,212,609	1,171,603	2,384,212	1.70
Ogun	1,847,243	1,810,855	3,658,098	2.61
Ondo	1,761,263	1,679,761	3,441,024	2.46
Osun	1,740,619	1,682,916	3,423,535	2.45
Oyo	2,809,840	2,781,749	5,591,589	3.99
Lagos	4,678,020	4,335,514	9,013,534	6.44
Sub-Total	**14,049,594**	**13,462,398**	**27,511,992**	**19.65**

Table 2.4: North-Central Geo-Political Zone

State	Male	Female	Total	% of the Nation
Benue	2,164,058	2,055,186	4,219,244	3.01
Kogi	1,691,737	1,566,750	3,258,487	2.33
Kwara	1,220,581	1,150,508	2,371,089	1.69
Nasarawa	945,556	917,719	1,863,275	1.33
Niger	2,032,725	1,917,524	3,950,249	2.82
Plateau	1,593,033	1,585,679	3,178,712	2.27
Sub-Total	**9,647,690**	**9,193,366**	**18,841,056**	**13.46**

Table 2.5: North-East Geo-Political Zone

State	Male	Female	Total	% of the Nation
Adamawa	1,606,123	1,561,978	3,168,101	2.26
Bauchi	2,426,215	2,250,250	4,676,465	3.34
Borno	2,161,157	1,990,036	4,151,193	2.97
Gombe	1,230,722	1,123,157	2,353,879	1.68
Taraba	1,199,849	1,100,887	2,300,736	1.64
Yobe	1,206,003	1,115,588	2,321,591	1.66
Sub-Total	**9,830,069**	**9,141,896**	**18,971,965**	**13.55**

Table 2.6: North-West Geo-Political Zone

State	Male	Female	Total	% of the Nation
Jigawa	2,215,907	2,132,742	4,348,649	3.11
Kaduna	3,112,028	2,954,534	6,066,562	4.33
Kano	4,844,128	4,539,554	9,383,682	6.70
Katsina	2,978,682	2,813,896	5,792,578	4.14
Kebbi	1,617,498	1,621,130	3,238,628	2.31
Sokoto	1,872,069	1,824,930	3,696,999	2.64
Zamfara	1,630,344	1,629,502	3,259,846	2.33
Sub-Total	**18,270,656**	**17,516,288**	**35,786,944**	**25.56**

Table 2.7: Federal Capital Territory, Abuja

FCT	Male	Female	Total	% of the Nation
Abuja	740,489	664,712	1,405,201	1.00

Table 2.8: Nigeria

Country	Male	Female	Total	% of the Nation
Nigeria	**71,709,859**	**68,293,683**	**140,003,542**	**100**

Source: http://www.nigeriamasterweb.com/Nigeria06CensusFigs.html retrieved on 23/9/2016

CONCLUSION

Nigerian forest cover has seriously diminished without replenishment. Under Nigerian Constitution, forestry is a state subject i.e. the various state governments own and manage the forest estate. Consequently, each state government enunciates its own policy and state policy only caters for the limited view point foreseen by each state government. There is no justification for enacting National Forestry Act without Federal Government owning its forest estate in each of the 36 states in Nigeria.

RECOMMENDATIONS

- Federal Ministry of Environment, Federal; Department of Forestry, States Forestry Services, Nigerian Universities where forestry is taught and other forestry stakeholders should of necessity have a national summit to address the problems militating against forestry sector in Nigeria.
- All 36 states as a matter of urgency and of necessity should set aside substantial fundss for forest regeneration on annual basis.
- Forest reserves in all the 36 states of the Federation be well monitored and evaluated to prevent further de-reservation.
- The Federal Government should liaise with all the 36 states in Nigeria for setting aside 50,000 hectares of land in each state for Federal Government Forest Estate in the immediate future

REFERENCES

Adeyoju, S.K. (1975) Forestry and the Nigerian Economy. Ibadan University Press. 308pp.

Adeyoju, S.K. (1978): Our forests and our welfare. Inaugural Lecture at the University of Ibadan, Nigeria.16 February, 1978. Ibadan University Press, Nigeria. 45pp.

Agbeja, B.O. (2004): The Need to Link State and Federal Forest Policies and Institutions in Nigeria. In: Rebuilding Africa's Capacity for Agricultural Development. The Role of Tertiary Education. World Agroforestry Centre, The Publication of the African Network for Agroforestry Education (ANAFE), Kenya, Pp.96-105.

Agbeja, B.O. and Verinumbe, I. (2006): Status of Forest Policies and Institutions in Nigeria: Implications for Synergy. Pp.264-271. In: Labode Popoola (ed.) Forestry at Crossroads in Nigeria. Proceedings of the 31st Annual Forestry Association of Nigeria held in Makurdi, Nigeria between 20th – 25 December, 2006.

Faleyimu, O. I. , Agbeja, B.O. and Akinyemi, O. (2008): Problems of effective forest policy implementation: the base of environmental degradation in Southwestern Nigeria. Proceedings of the second international conference on scientific and industrial studies. Vol. 2 (1) March,12-13, 2008. UNILAG, Nigeria.

FAO (2001): Global Forest Resources Assessment 2000. Main Report FAO Forestry Paper 140. Pp.115-124. Rome

(http://www.nigeriamasterweb.com/Nigeria06CensusFigs.html

http:www.globalforestwatch.org/country/NGA/1-37. Retrieved on 08/10/2016.

Rosevear, D.R. (1953): The Nigerian Handbook. Government Printer, Lagos.

UNEP (2006): Africa Environment Outlook 2: Our Environment, Our Wealth. Pp. 196-221.

SUB-THEME 1



Forest Management, Forest Investments and Agroforestry

Non-Timber Forest Products Governance for Improved Rural Livelihood in Nigeria

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ABSTRACT

This paper takes a look at the theoretical framework concerning Non-timber Forest Products (NTFPs) governance and its role in improving rural livelihood in Nigeria. It shows that NTFP governance has to do with the process of rule and decision making concerning production and marketing of NTFPs. It ensures equity of access and benefits obtainable from the exploitation of NTFPs. In doing this NTFPs governance help to promote sustainable forest management, protect forest resources from destructive use, promote communal peace, improves income earnings of rural dwellers and promotes increased rural well-being with the aim of helping to preserve the forest and by extension help to support rural livelihoods especially primary livelihoods like farming, hunting and fishing.

Keywords: Non-timber forest products, governance, rural livelihood

INTRODUCTION

From time immemorial forests have been providing many useful products to man. These products vary from timber products to fruits, ropes, leaves, honey and medicinal products. Among the diverse products provided by the forests NTFPs represents a significant part. NTFPs have been playing significant roles in the livelihoods of many rural households not only in Nigeria but all over Africa. NTFPs provide small but significant sources of income, particularly for women and for families that do not have access to agricultural markets (Central African Regional Programme for the Environment (CARPE), 2001). NTFPs also provide critical supplies of food during periods when agricultural crops fail or are otherwise scarce. NTFPs are so important that at a time NTFPs were seen as a possible 'magic bullet' to solve deforestation issues (CARPE, 2001). It is however, unfortunate that despite the significant roles of NTFPs to rural livelihoods its contributions have been largely neglected by policy makers and development planners. Oyun (2009) noted that despite the significant roles of NTFPs, there is no clear policy directed at NTFPs at any level of government in Nigeria. It is considered as minor or secondary forest products. In addition the management of many forest products has been neglected over the years by foresters and economic planners. Hence NTFPs have not been developed. Its management has been restricted to the local people and urban poor.

It therefore, follows that if the contribution of NTFPs to rural livelihood is to be improved, then access to it and its exploitation needs to be properly understood. As noted by Belcher *et al.* (2005) understanding of the role and potential of NTFPs to contribute to livelihood improvement and conservation objectives has been hindered by a lack of a clear theoretical framework and a functional typology of cases. This paper therefore tries to provide a clear theoretical framework about NTFPs and their governance with a view to creating a clear understanding about NTFPs that help to improve their exploitation and contribute more to rural livelihood.

Concept of NTFPs

Non-timber forest products (NTFPs) are biological resources other than timber, which are harvested from either natural or managed forests. Examples include fruits, nuts, oil seeds, latexes, resins, gums, medicinal plants, spices, wildlife and wildlife products. Others are dyes, ornamental plants, poles, raw materials such as bamboo and rattan (Nguyen and Bui, 2000). Wickens (1991) also defined NTFPs as all biological materials (other than industrial round wood, derived sound timber, wood chips, wood based panels and pulp) that may be extracted from natural ecosystem, managed plantations and be utilized within the household, be marketed or have social, cultural and religious significance. Chamberlain *et al:* (1998) defines NTFPs as plants, parts of plants, fungi and other biological materials that are harvested from within and on the edge of natural, manipulated or disturbed forests. Non-timber forest products include fungi, Moss, Lichen, herbs, vines, shrubs or trees. Many different parts are harvested including the roots, tubers, leaves, bark, fungi, branches, resin, fruits, seeds as well as the wood. NTFPs are plants and plant materials used for food, fuel, storage fodder, and

medicine etc. (Idumah *et al;* 2008). NTFPs are highly valued either for their leaves, roots, barks or fruits. They are the forest treasure that sustains rural dwellers by providing income, foods and medicinal materials. As a matter of fact majority of the rural poor all over Africa would have been showing obvious signs of malnutrition if not for the food provided by NTFPs to them in form of forest fruits and vegetables. Forest foods help to supplement and complement the daily diet of the rural poor.

NTFPs Governance Concept

Non-timber forest product (NTFP) governance is a concept that denotes the process of rule and decision making concerning production and marketing of NTFPs. It is more than rule making. It includes a broader societal process based on social practices, values and principles (Wiersum *et al.* 2013). This process is characterized by the coexistence of formal and informal institutions based on plural statutory, customary and market norms. Ros–Tonen and Kusters (2011) also defined NTFP governance as the multi-stakeholder and multilevel process of interactive decision making and creation of institutional frameworks for the allocation, use and trade of NTFPs. The concept of NTFP governance emerged as an analogous to the older concept of forest governance: a process that defines the purposes for which forests are managed and the conditions under which different stakeholders have access to decision-making and implementation processes (Lemos and Agrawal, 2006).

Kooiman and Bavinck (2005) use the term 'interactive governance' to refer to the interactive process between actors from the state, private sector and/or civil society at multiple scales aimed at 'solving societal problems and creating societal opportunities.' They distinguish between hierarchical governance, co-governance and self-governance, which correspond with Arts and Visseren-Hamakers (2012) distinction between governing by, with and without the state respectively. Forest governance was a concept that evolved out of the need to devolve the management of forest resources. It involves planning, utilizing and managing forest lands and resources through joint efforts of forest officials and the local community dwellers (Akinola, 2006). It is important that forest policies especially that of governance be tailored in a way that the primary focus will be on maintaining sustainability of the forest and at the same time meeting the needs of the local community dwellers living close to the forest. Neumann and Hirsch (2000) noted that it is difficult to conceive of developing principles for NTFP harvesting equivalent to those associated to harvesting of timber. Nevertheless what makes NTFPs different from timber and important as a conservation strategy is the assumption that the forests remain mostly intact and more or less biologically intact under sustained NTFP harvesting. This accounts for much attention given to commercial NTFPs as the foundation upon which to build policies of conservation and development (Neumann and Hirsch, 2000). According to Brown *et al*. (2002) local governance of NTFPs plays important role in reconciling concerns about dwindling forest resources and poverty among forest dwelling people. The dwindling forest resources and poverty among the forest dwelling people was a concern because it was thought that poor people may result to massive exploitation of NTFPs which may have negative impact on the forest ecosystem. However commercial exploitation of NTFPs has been recognized as an activity that has minimal impact on the forest (Peters *et al*, 1989) and it can as well play important role as a source of food and a source of income in situations where alternative livelihood activities are scarce (Sunderlin *et al*., 2005).

It is important to note that the concept of NTFP governance was given prominence due to much attention that has been given to NTFPs recently. Non-timber Forest products (NTFPs) have for long been neglected by development planners in the development plans for Nigeria. Attention has majorly been focused on timber products. However in the past few decades attention has changed to NTFPs. It seems foresters and development planners have suddenly realized the importance of NTFPs more than ever before in the support of many livelihoods and in the supply of many benefits to many people. Some of the benefits include medicinal, cultural and social including provision of income to many forest dependent people. Belcher *et al*. (2005) noted that increased interest in NTFPs began in the late 1980s and early 1990s in conjunction with increasing global concern about environmental issues especially deforestation, with increased attention on rural poverty and with the emergence of the concept of sustainable development.

How NTFP Governance can Improve Rural Livelihood?

Common rural livelihoods in Nigeria include farming, hunting, fishing, handcraft, goldsmithing and blacksmithing. One prominent characteristics of these livelihoods is that they are small scale and of low income (Adedayo, 2002). This has not augured well with many rural dwellers in Nigeria. As a matter of fact this has been the core reason why many rural dwellers are poor and live in a state of hopelessness. It therefore follows that there must be a better way of utilizing NTFPs in order to improve the income earning potentials of NTFPs to the rural dwellers.
Among other things, NTFP governance can help to improve rural livelihood through the following ways:

1. **NTFP Governance promotes sustainable Forest Resources Management:** Sustainable forest resources management is critical to ensuring sustainable rural livelihood. Warner (2000) noted that sustainable use of natural resources is critical to sustainable livelihoods. He stated further that forests contribute to livelihoods by providing materials for construction, baskets, storage structures, agricultural implements, boats and hunting and fishing gear. They provide inputs for farming systems such as fodder and mulch, contribute to soil nutrient cycling, help to conserve soil and water and provide shelter and

shade for crops and animals. NTFP governance promotes sustainable forest management because it involves rural dwellers in the management of NTFPs. This help to promote their sense of belonging and their readiness to be involved in the protection of forest resources generally. This help to boost sustainable forest resources management which in turn helps to support rural livelihoods. It should be noted that sustainable agriculture is not possible without sustainable forestry. Sustainable forestry is not possible without proper protection of the forest and proper protection of the forest is not possible without the involvement of rural dwellers. The reason is because rural dwellers know the local terrain where forest reserves are located better that forest guards. They are therefore in a better position to secure forest reserves than government employed forest guards.

2. **NTFP Governance helps to Protect Forest Resources;** NIFP governance can help to protect forest resources from destructive use. Though this might be an indirect role of NTFP governance, it is still a very important role of NTFP governance. This is because NTFP governance will make rural dwellers to see themselves as partners in progress with government over the management of forest resources located on their land. The reason for this is because NTFP governance will help to improve the sense of belonging among rural dwellers for the mere fact that they are involved in the management and sharing of benefits of NTFPs on their land. This will help to change their orientation and attitude towards forest resources generally. Hitherto many rural dwellers used to have a wrong notion that government's property is nobody's' property and as such it is subject to destruction and sometimes looting NTFP governance will therefore help to boost the morale of rural dwellers in the protection of forest resources generally. When forest resources are protected from destructive use they help to support many other rural livelihoods especially farming and hunting.

3. **NTFP Governance helps to Promote Communal Peace:** Peace is a phenomenon that every society strives to have. This is because peace brings development and progress to the society. As a matter of fact businesses as well as forest management and other rural livelihoods can only take place under a peaceful atmosphere. Achieving this peace seems to be a herculean task judging by the daily occurrence of conflicts. all over the country However NTFPs governance can help to bring peace through the involvement of members of the community in the taken of decisions in the management and utilization of NTFPs as well as in the sharing of the benefits. NTFP governance can help to bring peace by helping to prevent conflicting claims over ownership or access to NTFPs and by extension other forest resources. This role of NTFP governance is a non-quantifiable role which is of extreme importance.

4. **NTFP Governance helps to improve income earnings of rural Dwellers**: Livelihoods are expected to be able to provide income that will meet the basic necessities of life. However the dwindling forest estate in the country has reduced drastically the capacity of rural livelihoods in providing income at a level that will meet basic rural household needs.. As such many rural livelihoods are no longer sustainable due to low income generation and reduced forest estate. It is known that the forest estate help to support rural livelihoods both directly and indirectly. The reason for this is not unconnected with the fact that majority of the rural livelihoods are primary livelihoods. That is they are dependent on land and forest. It therefore follows that forest degradation affects rural livelihood. This shows that the state of the forest has both direct and indirect influence on rural livelihoods. Exploitation of NTFPs is known to have a minimal impact on forest degradation. Peters *et al*. (1989) noted that exploitation of NTFPs has a minimal impact on the forest. It therefore follows that the exploitation of NTFPs can be used to preserve the forest which in turn will help rural livelihood. NTFP governance can then be used to improve rural livelihoods by helping to improve the income generated by rural households from their livelihood. Sunderlin *et al* (2005) noted that exploitation of NTFPs plays an important role for the rural poor as gap filler and source of income in situations where alternative livelihood activities are scarce. Researches have shown that local governance of NTFPs can play significant role in poverty reduction and improved livelihood among rural households (Brown *et al*., 2002; Mayers and Vermeulen, 2002 and Oyun, 2009).

5. **NTFP Governance promotes increased well-being:** NTFP governance help to promote increased well being among rural dwellers. Increased well being of rural dwellers can have both direct and indirect impact on rural livelihoods. When the well-being of rural dwellers is increased it will also affect the well-being of the forest. This in essence means the forest will be preserved. NTFP governance can improve people's well-being by improving their access to resources, increase their income as well as self esteem and political power. Warner (2000) noted that sense of well-being is affected by numerous factors including self esteem, sense of control and inclusion, health status, access to services and political enfranchisement. He went further to state that forestry initiatives that support access to resources, particularly decision making and equity assist in increasing well-being, especially that of the poor. This is exactly what NTFP governance does. It supports access of rural dwellers to NTFPs and ensures equity in the distribution of benefits thereby helping to increase their income. The significance of this is that increased well-being among rural dwellers will help to reduce deforestation and other forms of forest destructive use. Sheperd (1992) noted that it is beginning to be accepted that the well-being of the forests .and the people heavily dependent upon them, are closely intertwined. In the same vein de Ceara (1986) noted that the only means of stabilizing the ecosystem is to stabilize the social system; to solve the reforestation problem one must solve the poverty

problem. From the foregoing it therefore follows that NTFP governance will help to support forest conservation and by extension it will help to support primary rural livelihoods .like farming, hunting and fishing.

CONCLUSION

This study has shown that NTFP governance is a concept that seeks the involvement of members of the community in the management and taking of decisions on the use of NTFPs as well as sharing of the benefits derivable. In doing this NTFP governance help to support sustainable forest resources management, it helps to protect forest resources from destructive use, promote communal peace, improves income earnings of rural dwellers and promotes increased rural well-being. All these roles of NTFP governance help to preserve the forest and by extension help to support rural livelihoods especially primary livelihoods like farming, hunting and fishing.

REFERENCES

Adedayo, A. G. (2002). Forest Resources Utilization and its impact on Rural Livelihood in Kwara State, Nigeria. Unpublished M. Agric. Tech Thesis of the Department of Forestry and Wood Technology, Federal University of Technology Akure, Nigeria. 146pp.

Akinola, S. R. (2006). Land Use Decree, Forest Administration and Governance crises in Nigeria. Http/www.fig.net/pub/accra/papers//ts01/ts01_04_akinolapdf.

Arts B, V. and Visseren-Hamakers, I. (2012). Forest governance: a state of the art review. In: Arts B, van Bommel S, Ros-Tonen M, Verschoor G, editors. Forest-people interactions: understanding community forestry and biocultural diversity. Wageningen: Wageningen Academic Publishers. pp. 241– 257.

Belcher. B., M. Ruiz Pérez and R. Achdiawan (2005) 'Global patterns and trends in the use and management of commercial NTFPs: implications for livelihoods and conservation.' World Dev 33(9):1435-1452.

Brown, D, M. Schreckenberg, G. Shepherd and A. Wells (2002): Forestry as an entry point for governance reform. ODI Briefing Paper 2002(1).

Central African Regional Programme for the Environment (CARPE) (2001): Non-Timber Forest Products Economics and Conservation Potential. Comgo Basin Information Series Issue Brief No 10 March, 2001.Pp.10.

Chamberlain, J.L., Bush, R. and Hammett, A.L. (1998): Non-Timber Forest Product: The other Forest Products. *Forest Product Journal*.48 (10): 2-12.

de Ceara, I. (1986): Land Tenure and Agroforestry in the Dominican Republic. *Social Forestry Network* Paper.3d. Overseas Development Institute.

Idumah, F.O., Onyeanusi, A.E. and Ajayi, C.A (2008): Non-Timber Forest Resources and Sustainable Livelihood in a Rural Economy. In: Agbogidi, O.M *(Ed): Proceedings of the 2nd Biennial National Conference of the Forests and Forest Product Society.* 26th-29th April, 2010. Pp. 372-378

Kooiman, J. and Bavinck, M. (2005). The governance perspective. In: Kooiman J, Bavinck M, Jentoft S, Pullin R, (editors). Fish for life: Interactive governance for fisheries. Amsterdam: Amsterdam University Press (MARE Publication Series vol. 3).11-24

Lemos, M. C. and Agrawal, A**.** (2006). 'Environmental governance', Annu Rev Environ Resour, **31**:297–325.

Mayers, J. and S. Vermeulen (2002) Power from the trees: how good forest governance can help reduce poverty, London: WSSD Opinion, IIED.

Neumann, R. P. and Hirsch, E**.** (2000) Commercialization of non-timber forest products: Review and Analysis of Research, Bogor: Center for International Forestry and Rome: FAO.

Nguyen, T. N. and Bui, T. A. (2000): Non- Timber Forest Products (NTFPs) - Gender Analysis & Gender Action Plan. NTFP Project, 8 Chuong Duong Do, Hanoi, Vietnam, 2000.

Oyun, M.B. (2009): The Role of Non-timber Forest Products on the Livelihoods of Fringe Communities of Idanre Forest Reserve, Nigeria. *Forests and Forest Products* Journal, 2: 6"-75, 2009.

Peters, C.M., A.H. Gentry and R.O. Mendelsohn (1989) 'Valuation of an Amazonian Forest', Nature 339: 655-656.

Ros-Tonen, M. A. F. and Kusters, K**.** (2011). Pro-poor governance of non-timber forest products: the need for secure tenure, th rule of law, market access and partnerships. In: Shackleton S, Shackleton C, Shanley P, editors. Non-timber forest products in the global context. 1sted. Heidelberg: Springer Tropical Forestry Series, **7**: 189 – 207

Shepherd, G. (1992): *Forest Policies, Forest Politics*. Publish by Overseas Development Institute Occasional Paper 13 London. Pp.84.

Sunderlin, W., Angelsen, A., Belcher, B., Burgers, P., Nasi, R., Santoso, L. and Wunder, S. (2005).'Livelihoods, forests, and conservation in developing countries: an overview. World Development, **3** (**9**):1383 – 1402.

Warner, K. (2000): Forestry and Sustainable Livelihood. *Unasylva* 202 vol.51 (1) 3-12.

Wickens, G.E. 1991 Management issues for development of non-timber forest products. Unasylva 42(165): 3-8.

Wiersuma, K. F., Ingramb, V. J. and Ros-Tonen, M. A. F. (2015). Governing access to resources and markets in non-timber forest product chains. *Forests, Trees and Livelihoods*. http://dx.doi.org/10.1080/14728028.2013.868676. Cited on 27 -06-2015

Community Involvement in Forestry and Rural Development in Ejigbo and Ola-Oluwa Local Government Areass of Osun State

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ABSTRACT

This study was carried out to evaluate the Community Involvement in Forestry and Rural Development in Ejigbo and Ola-oluwa Local Government Area of Osun State. One hundred and twenty questionnaires were administered randomly to selected respondents from each of the ten (10) villages/communities in the study areas based on their size. The data obtained were analysed using frequency distribution, percentages and bar charts. Results revealed that 63.33% of the participants were males while the remaining 36.66% were females. It also showed that major project participated by the respondents in the study area were maintenance/rehabilitation of feeder roads, group farming and construction of community fish ponds project constituting 4.17, 39.17 and 34.15%,, respectively. The study also revealed that 50 respondents practised forestry through woodlots management, 37 respondent practice home garden systems of agro forestry, 13 respondents practised forestry through nursery development, 10 respondents practised boundary tree, while 6 respondents practised apiculture. The major factors contributing to involvement level in the study area were age, gender of major participants, occupation, marital status, educational attainment, awareness and society membership of participants. These factors were project specific and only educational attainment was found to have a negative impact on the participatory level. The study revealed that the involvement level still needs to be improved in the study area and effort should be made to increase the participatory level for increasing the standard of living.

Keywords: Forestry practice, rural development, community involvement, agroforestry

INTRODUCTION

The community involvement in forestry activities has been ignored by planners and policy makers not only in Nigeria but also all over African (Adedayo and Oyun, 2010). The population of developing countries depends largely on forest products and agriculture for livelihood. They urgently need development, to improve food security. Agriculture has been the main stay of Osun's economy over the decades, especially since the giant strides made by the old Western Region Government. However, very little progress has been made over the years in building on this foundation to transform the economy of the state using agriculture as a driver. Due to a lack of focus in the agriculture sector, the gains achieved by the Western Region government have been gradually eroded (Ministry of Information, Osun State, 2009). Rural areas offers a lot of opportunities, especially to young people, among which are: stable structures, close links to decision makers, people who know how to bring ideas into reality and an atmosphere full of creativity (ILO, 2005; World Bank, 2007). Hence, local people have an important role in agriculture, their involvement in forestry varies between cultures, but in most cases there are few major agricultural operations in which they do not participate but in their involvement, the agrarian farmers as well as industrialized societies have sophisticated ways of looking at the world. They have names for many different kinds of plants, ways to diagnose and treat human and animal diseases and methods to crop fertile and infertile soils. Therefore, it is no longer encouraging to be saying that the rural dwellers that grow the bulk of our food are yet to transform their traditional mode of production and this is why majority of the farmers are still practicing subsistence agriculture. This method of agricultural production even though crude and highly primitive were usually well adapted to local environment, involving minimum risk and ensuring enough food for the family (Arnon, 2007). This study therefore examine the community involvement in forestry and rural development

MATERIALS AND METHOD

The study was conducted in the rural area of Osun State, Nigeria. The study area lies within longitude 2.75^0 and 6.75^0 Greenwich meridian and latitude 7^0 and 9^0 (Ministry of Information, Osun State) According to analytical report of the National Population Commission (2006), Osun State has 3,423,535 people with thirty (30) local government areas and one area office out of which two local government areas were selected. They are: Ejigbo local government area with its headquarters at Oko road and Ola-oluwa local

government area with its headquarter at Bode-Osi. The following towns surround it, Ogbomoso on the North, iwo in southwest and Ede in the Southeast. The town is about 38 kilometers from Osun State Capital, Osogbo, adjoining local government areas are: Ola-oluwa, Egbedore in Osun State.

Sampling procedure and sample size

The sources of data were primary and secondary. The primary data were collected through interview schedules which were administered on the participants of the community involved in forestry (respondents). The secondary data were collected from state forestry Osun state Osogbo. Collection of data was carried out from ten (10) selected communities such as Arogbo (12), Elepetu (12), Olodan (14), Fagbola (10), Amukoko (15) Telemu (9), Iwara (15), Obamoro (12) and Ajagunase (15) all within the study area, purposive random sampling technique was used to select respondent from each communities. One hundred and twenty (120) respondents were selected and interviewed. Descriptive statistics such as frequency distribution, percentages and bar charts were used to analyse the data collected.

RESULTS AND DISCUSSION

Table 1: Demographic Characteristics

Variables	Frequency	Percentage
Age (years)		
Less than 20	16	13.33
20-40	16	13.33
30-40	76	63.33
40 and above	12	10.00
Total	120	100.00
Marital status		
Single	24	20.00
Married	92	76.67
Divorced	2	1.66
Widowed	2	1.66
Total	120	100.00
Education		
No formal education	38	31.67
Primary	16	13.33
Secondary	42	35.10
Tertiary	4	3.33
Adult education	20	16.67
Total	120	100.00
Occupation		
Farming	72	60.00
Trading	28	23.33
Tailoring	12	10.00
Others (specify	8	6.67
Total	120	100.00
Gender		
Male	76	63.33
Female	44	36.66
Total	120	100.00
Membership		
Member	72	60.00
Non-member	48	40.00
Total	120	100.00

Source: Field survey, 2012

Table 1 showed the age distribution of respondents in the study area. The mean age was 35 years while most of the participants were above 30 years of age (91percent). The ages of most of the participants were between 20-40years. This means that this age group participates more in farming activities in the study area and is likely to be very active. This study confirmed the report of Adekunle, (2009) which stated that people in this age group (31-50 years) are agile and gainfully employed in farming, hence their involvement in agro-forestry practice.

Table revealed the distribution of participants by marital status in the study area. Majority of the participants about 76.67percent were married. The divorced and widowed were 1.66 and 1.66 percent, respectively. It therefore, showed that married people are more involved in forestry and rural development projects implementation than bachelors, widowed and divorced people due to the fact that married people were more stable in the study area and their participation would improve their standard of living which is the major impact it has on them. From the table it could be observed that about 31.67percent of the respondents had no access to education. The proportion of the participants that attained primary and secondary education were 13.33 percent and 35.10 percent, respectively, while the proportion of the participants that attained tertiary and adult education level were 3.33 percent and 16.67 percent, respectively. This revealed that the literate level of the participants in the study area was above 70 percent; average which has enhanced increased participation of the people in the study area. Therefore, as the level of education attainment increases also level of participation increases.

Table 1 further revealed majority of the participants about 60percent were engaged in farming while those engaged in trading constituted about 23.33 percent, tailoring 10percent and others 6.67percent. In the table, farming constituted the bulk of occupation of the rural dwellers followed by trading. The bulk of those engaged in farming were involved in forestry and rural development. The distribution of the participants according to gender in the study area indicated that 63.33percent were males while 36.66percent were females. It was observed that there should be a particular involvement of women participation for some reasons since the projects to be implemented affected both men and women. Therefore, both of them should be participating. The low percentage of females might be due to the fact that females were involved more in household work and taking care of children while males were more involved in the project work than their female counterpart because males took farming as their primary occupation in the study area.

Table also revealed that the majority of participants in forestry and rural development in the study area were involved in associations/societies. They constituted about 60.00percent while those who were not in any organization constituted about 40 percent. This result showed that societies really play an important role in motivating people in the study area to participate in projects. This is in line with Uphoff *et al* (2012) that participation through organization, unions or institutions is more likely to be effective and sustained than individual participation.

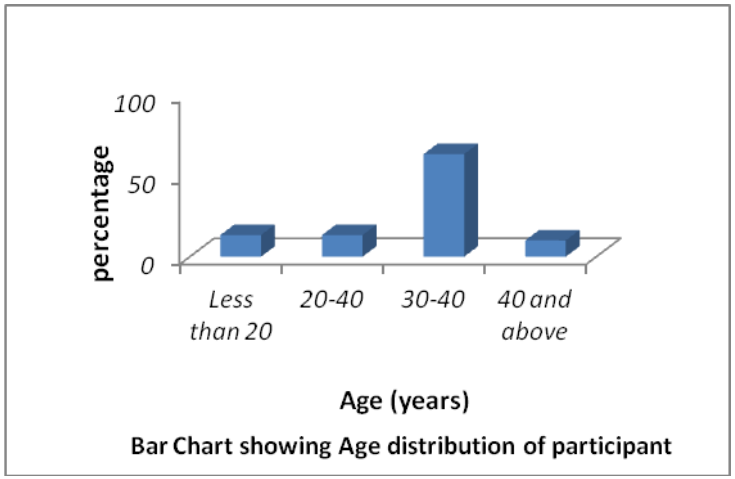


Figure 1: Showing Age distribution of participants

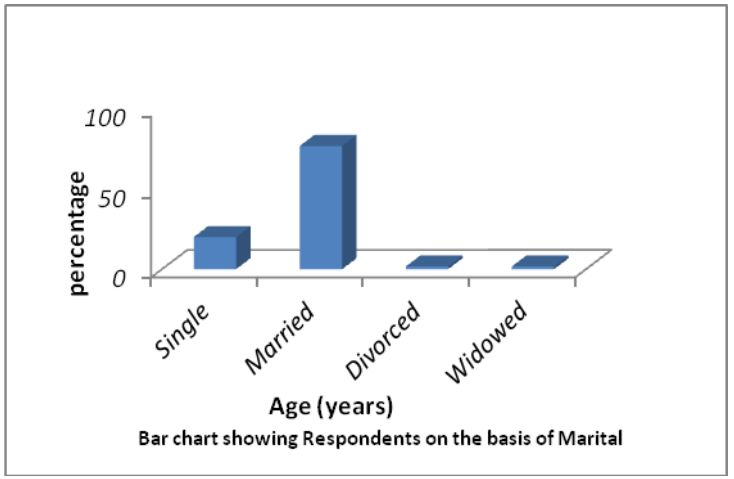


Figure 2: Respondent on the basis of Marital

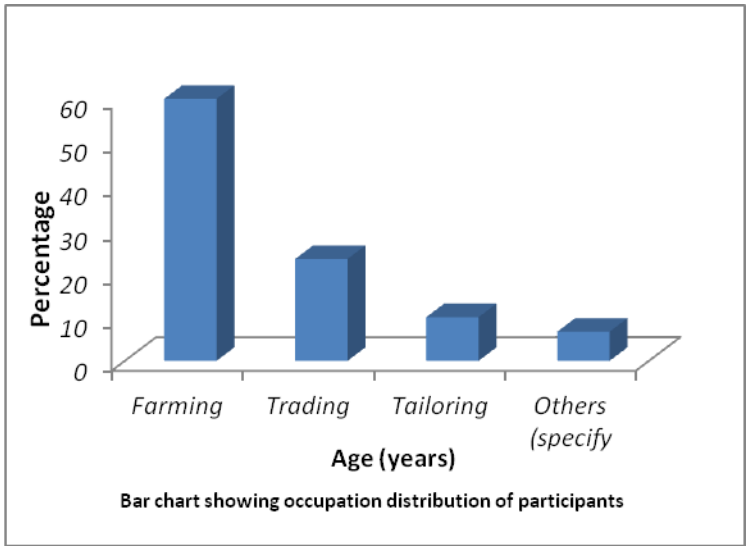


Figure 3: Occupation Distribution of Participants

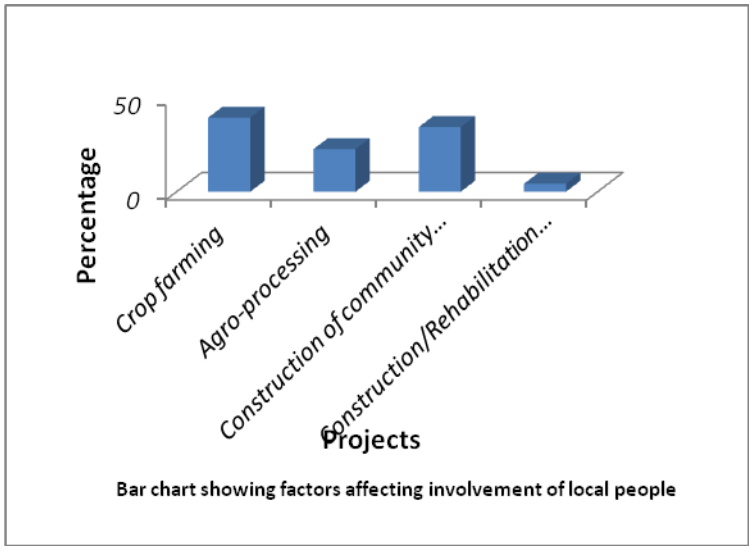


Figure 4: Factors Affecting Involvement of Local People

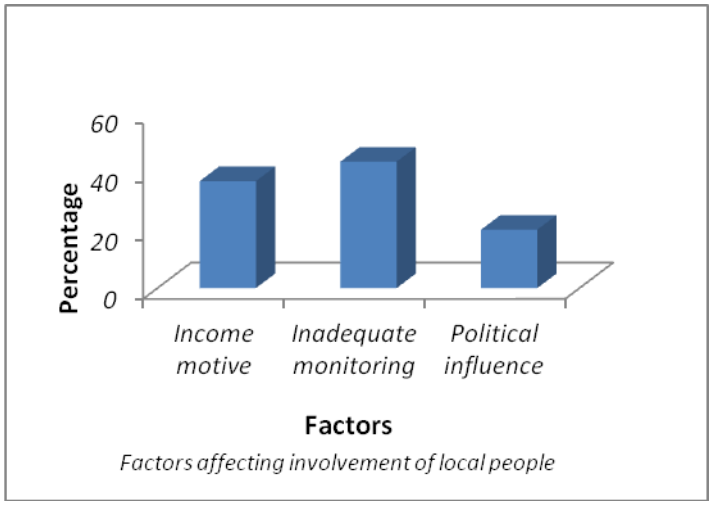


Figure 5: Factors Affecting Involvement of Local People

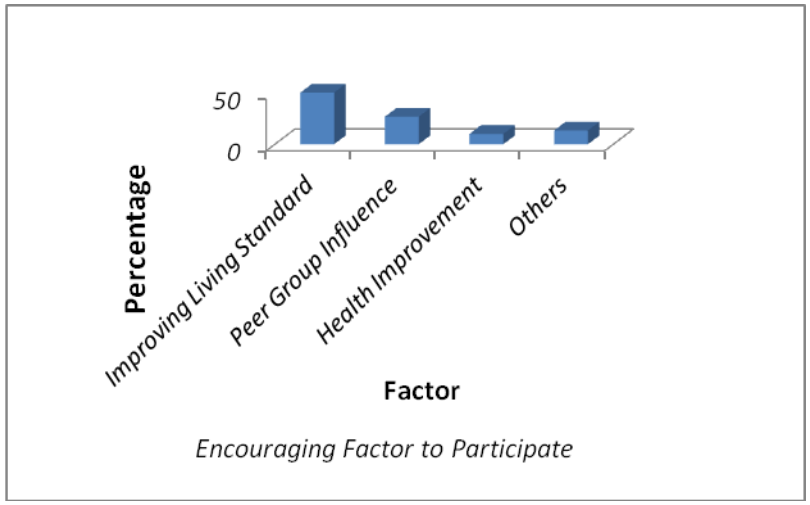


Figure 6: Encouraging Factor to Participate

Table 2: Non-Demographic Variables

Variables	Frequency	Percentage
Involvement level		
10-20	30	25.00
20-30	44	36.67
30-40	26	21.67
40-50	16	13.33
50 >	4	3.33
Total	120	100.00
Forestry practice		
Woodlot mgt	50	41.5
Nursery Development	13	10.8
Home garden	37	30.8
Boundary trees	14	11.7
Apiculture	6	5
Total	120	100
Projects		
Crop farming	47	39.17
Agro-processing	27	22.50
Construction of community fish pond	41	34.15
Construction/Rehabilitation of Agricultural Feeder Roads	5	4.17
Total	120	100.00
Factor		
Income motive	44	36.67
Inadequate monitoring	52	43.33
Political influence	24	20.00
Total	120	100.00
Improving Living Standard	60	50.00
Peer Group Influence	32	26.67
Health Improvement	12	10.00
Others	16	13.37
Total	120	100.00

Source: Field Survey, 2012

Table 2 revealed the frequency distribution of the participants' level of involvement in the study area. The involvement levels of most of the participants ranged between 20 - 30 years. Community involvement in forestry and rural developrnent in the study area was handled by the active age. Table 2 showed the frequency distribution of the projects identified in the study area. It was revealed that about 4.17 percent of the participants participated in the construction/rehabilitation of agricultural feeder roads in the study area which facilitated easy transportation of the farmers products to the market, about 22.50 percent of the participants were involved in agro-processing projects in order to improve the provision of food to the rural people. Group farming project constituted about 39.17 percent which include raw method of farming such as demonstration plot and planting of new improved seed and seedlings to increase farmers income and productivity while construction of community fish pond project constituted about 34.16 percent.

From table 2, the major factor limiting people's involvement in the study area was inadequate monitoring by extension agents. This greatly discouraged many participants to participate in the project. Another factor was the income motive which made some participants to lose interest due to non-monetary reward from participating in the project. Respondents (36.67percent) believed that their interest was limited despite of lack of financial assistance to the individuals. The least factor could be attributed to the political influence which 20percent of the participants were discovered affected in participating towards the successful implementation of the programme within the study area.

It was observed that improvement in standard of living which constituted about 50percent was the major factor that encouraged the respondents, followed by peer group influence, Health improvement and others which were 26.67percent, 10percent and 13.333percent, respectively. The major problem facing the participation of people involvement in forestry was greatly due to inadequate monitoring by extension agent (43.53percent), and this resulted into a setback in executing the project. Therefore, the community was reluctantly participating in project execution due to inadequacy in project monitoring .Income motivation for beneficiaries was another factor that greatly inhibited the participation of people in project execution because most respondents believed in monetary reward for any work done and while the participants seldom participate in community involvement in

forestry and rural development projects. The political influence was the least factor (at about 20percent) which made the respondents to be unwillingly participate at times in the involvement projects in the study area.

Table 2 showed that 50 respondents were into woodlots management; 13 respondents were into nursery development; 37 respondents were practicing home garden system of agroforestry, 14 respondents were into boundary trees practice; and 6 were into the practice of apiculture. The study also showed that there were few involvements in nursery development because there was no immediate income and food for household, unlike woodlots management that money could be realized from the sales of fruits, fuelwood and soup condiments on daily basis. They would have to wait for the seedlings to be ready for sales and this could take months depending on the species of trees. There were fewer involvements in apiculture due to the hazard nature of bees and lack of income to invest in hives and harvesting materials (Udofia, 2011).

CONCLUSION

The major factors contributing to involvement level in the study area were age, gender of major participants, and kind of occupation, marital status, educational attainment, awareness and society of participants. These factors are project specific and only educational attainment was found to have a negative impact on the participatory level. It can also be concluded that while some people participated voluntarily because of their need for the particular community involvement in forestry and rural development projects such as improvement in standard of living, health, peer group influence of the rural dwellers, others participated because of government encouragement through provision of incentives and input subsidized rate to the farmers in the study area, hence Government can further enhance involvement of the people by making education available, improving infrastructural facilities. Cooperatives/societies should be encouraged and motivated to become more involved in the implementation of the projects to develop their communities. Project planners should take into consideration of the people's needs for the project as this will get them more involved in the implementation of the projects. There is need for the government to provide better credit facilities, provision of better income earning job to get more people to participate in community involvement in forestry.

REFERENCES

Adedayo, A.G., and Oyun, M.B., (2010): The involvement of Rural Women in Forest Resources exploitation in Ondo State, Nigeria. In: Onyekwelu, J. C, Adekunle, V.A.J and Oke, D.O (Editors) climate change and forest resources management; the way forward. *Proceedings of the 2nd Biennal National Conference of the Forest and Forest Products Society*, Pp. 140 -144

Adekunle, A.A., (2009). Integrated Agricultural Research for Development (IAR4D). A concept paper prepared for Forum for Agricultural Research in Africa (FARA), Sub-Saharan Africa Challenge Programme (SSA CP).

Adeniyi, E.O (2000). An overview of Rural Development Project in Nigeria. The case of Kanji Dan. *Journal of the federal Department of Rural Development* Vol. 5, No.1. Dec. 2007.

Arnon, I. (2007). Modernization of Agriculture in Development Countries, Resources, Potentials and problems: 2nd Edition, 471pp.

ILO, (2005). Global employment trends for youth, Geneva, ILO. www.vwec.ILO/sowreports_30/5/2008

Ministry of Information, Osun state (2009). File: Osun State, Nigeria. Available: www.osunstateorg/ministries/mininfowmen.htm 22/6/2009.

National Population Commission's Population figures for Nigeria States for 2006 population and Housing Census. May 26, 2013. https://www.jstor.org/stable/25434601

Udofia, S.I (2007): Status of Home Garden in Akwa-ibom State, Nigeria unpublished PhD Dissertation, Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria Pp.45-62.

Uphoff, N and J. Cohen (2012): Community participation in approaches to community participation in Agricultural and Rural Development. An EDI Review paper, World Bank, Washington D.C

Williams, P.J. (19920: Non- Governmental Organization, Women and Forestry Activities in Africa. *Unasylva*, 43 (171): 41-49.

WorldBank (2007). Executive Summary in Worldbank. Rural Development: From vision to action, the next generation, Worldbank, Washington, D.C

Ensuring Successful Expected Outcomes from Implementing Participatory Techniques in Managing Renewable Natural Resources: Lessons from Experience

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ABSTRACT

The management strategies of most West African forests and some other renewable natural resources have been noted to have historical antecedence in colonial legacy that placed more emphasis on managing the resources on behalf of other stakeholders, most especially those considered to be the indigenous traditional owners. However, recent studies have shown that these antiquated strategies are not giving the expected outcomes in terms of satisfying the often diverging interests of the different stakeholders including inability to ensure forest sustainability as it concerns sustainable resource production for present and future generation. This challenge has however led to the suggestion and introduction of various types of participatory techniques, based on informed positions, in managing these renewable natural resources. Owing to the fact that these participatory techniques are designed to be driven by human institutions, it should not be unexpected that there will be some implicit challenges even in the best designed techniques, as has been observed in some of the implemented participatory approaches in some developing countries. Nevertheless, involving all stakeholders in managing renewable natural resources is the right way to go if sustainability of the resources is to be ensured. Thus, the challenges encountered during the implementation of these participatory techniques should be surmounted. This article was written to contribute to the efforts in this regard by documenting some salient factors contributing to some cases of successful accounts of applying participatory approaches at managing renewable natural resources, most especially forests, in some developing countries. In addition, some lessons learnt as a result of implementing participatory approaches for managing renewable resources were highlighted bearing in mind how some of the challenges encountered were surmounted including possible bottlenecks that might need future solutions with particular relevance to West African sub-region.

Keywords: Participation, renewable natural resources, forest management, sustainable strategies

INTRODUCTION

Apart from the earlier appointment, in 1886, of an officer by the British colonialists to take charge of the forests of the Colony and Protectorate of Lagos under the then Governor, Sir Alfred Moloney, the Nigerian Forest Department was actually created in 1899 principally because the erstwhile colonial government claimed to be alarmed by the wanton destruction of the country's forests for farming and uncontrolled felling of a few tree species mainly those that were mahogany. The initial forestry efforts after the demarcation and consolidation of reserves were therefore directed towards the development of an adequate area of forest reserves to produce sufficient timber on a sustained yield basis (Onweluzo, 1988; Forestry Association of Nigeria - FAN, 1989) mostly for export to the European market.

With the later constitutional changes that took place in colonial Nigeria in the early 1950s, the post of the Inspector-General of Forests was abolished simultaneously with the creation of three autonomous regional Forestry Services i.e. Northern, Eastern and Western (Onweluzo, 1988). Administration, management and development of the forests estates were left solely with these regional forestry services, a situation that still obtains in all the present day States of the Federation that inherited these forest reserves and protected areas. These forest reserves and protected areas were actually set up and backed by laws while most of the forests that were not reserved are actually under the "ownership" of government in many West African countries through laws.
An example of such laws is a forestry code, passed on 4 July 1935 (République de Côte d'Ivoire, 1949) that handed more responsibility for the forests in the region to the French West African Forest Service (Coulibaly-Lingani, 2011). Under this decree, all or part of the land classified as forest was to be exempt from human use. Local communities were seen as a threat to the environment and the location of villages close to classified forests was discouraged (Foury, 1948). After independence, forest codes of the new State adopted the principles of the 1935 Decree, and established forests as properties of the State (Bertrand, 1991). These forests were first and foremost seen as the "property" of government that are to be managed by its appropriate agencies for the benefit of "all".

Another example of such laws is the Land Use Act (formerly Land Use Decree promulgated on 29th of March, 1978) in Nigeria that seemingly excluded many of the stakeholders, mostly the indigenous traditional land owners and those living within or at the fringes of these forests whose livelihoods are mainly dependent on these forests. Similar occurrence was experienced in many Francophone West African countries, with varying degrees of State tenure and control over forest and tree resources, and often tree-bearing land, in the colonial and postcolonial periods (Coulibaly-Lingani, 2011). In a series of land-tenure laws enacted in 1825, 1848 and 1899, the French West African colonies claimed forests as State property, and the first forestry code, issued in 1900, confirmed colonial State control of forests (Agrawal and Ribot, 1999).

In other words, the central theme of most forest policies in West African countries revolves round the phrase "Forests are being managed on a sustained basis for the benefits of the society/people" irrespective of the fact that essentially all forests, however remote and seemingly physically unoccupied, have traditional owners and users. The idea behind setting up these forest reserves might be laudable in the past and perhaps even presently, but realities have shown that there are almost always conflicts between the different stakeholders and government as it concerns the different uses to which these forests are put. There are concerns that challenges still exist concerning criticisms that points out failure to address deeper issues of power relations between national/central policies and realities on ground (Balooni, 2002; Neef, 2003; Paudel *et al*., 2007).

Similarly, there is also a highly skewed power structure in favour of governments and the industry interested in resources exploitation on one hand and marginalised local communities on the other. For instance, in cases whereby government policies have awarded certain groups concessions, licenses, and permits, limiting (or in some cases denying) the rights of poor local inhabitants the access into forest reserves and protected areas, conflicts are bound to happen, as these poor people are mainly interested in other services and products the forests have to offer such as non-timber forest products like plants, snails, mushrooms, or fruits, among others that may not negatively affect forest sustainability, but in most cases those with these access rights do not always have interest in.

Recent experience has shown that the development and implementation of forest management related policies through appropriate and adequate participatory process is a panacea to these conflicts. It is noteworthy that involving local inhabitants in sustainable forest management is not a totally new recommended necessity except that there are recent modifications to the conceptual framework. For example, as far back as 1977, the World Bank Forestry Sector Review (World Bank, 1978) noted that many forestry projects failed without the collaboration of local residents and that their collaboration improved environmental outcomes. It stressed the need to learn more about how to support policies that successfully give management and benefits to smallholders and the need to better understand local use, forestry-related practices, and traditional institutions.

Furthermore, studies have also been able to show that in some cases where participatory processes are involved in the management of forests and other renewable natural resources, for one reason or the other, some groups or individuals may be neglected or unintentionally left out from benefiting from the accompanying advantages. In line with these observations, there is therefore the need not only to intensify efforts at developing appropriate participatory process for sustainable management of these forest reserves and protected areas coupled with increasing awareness and acceptance of these processes in the different countries of West Africa but also to increase efforts at eliminating challenges that might arise as a result of adopting and/or adapting these processes in local scenarios.

This article is therefore aimed at contributing to these efforts by highlighting some factors contributing to some cases of successful accounts of applying participatory approaches at managing renewable natural resources, most especially forests, in some developing countries. Forest in this context is used to encompass diverse types, from dry woodlands to moist tropical forests, coastal mangroves and plantations. In addition, some lessons learnt as a result of implementing participatory approaches for managing renewable resources in other climes were highlighted bearing in mind how some of the challenges encountered were surmounted including possible bottlenecks that might need future solutions with particular relevance to West African sub-region.

Successful Participatory Forest Management Strategies: Some Factors

Record has it that there have been efforts at implementing and institutionalising some forms of collaborative forestry and community participation systems in some West African countries such as Benin Republic, Burkina Faso, Cote d'Ivoire, Ghana, Guinea Conakry, Mali, Niger, Nigeria, The Gambia, among others, with various levels of success and challenges (Bush, 2000; Djodjouwin, 2000; Kerkhof, 2000; Lorng, 2000; Montagne and Mamoudou, 2000; Wily and Hammond, 2001; Gambia German Forestry Project - GGFP 2001; Saarela-Kaonga, 2001). These efforts, whose origins in West Africa can be traced to the late 1970s and early 1980s, responded to, among other concerns, the failings of forestry policies throughout the world, including the alienation of rural people as a consequence of series of exclusionary forestry policies (Westoby 1987; Peluso 1992; Amanor, 2004).

Studies have shown that the early developments of almost all the participatory approach strategies aimed at managing forests and other renewable natural resources tend to engage communities, particularly the rural inhabitants, as local users whose cooperation was sought and bought through making some of their forest access legal and/or through sharing with them a portion of income generated from forest enterprises (Coulibaly-Lingani, 2011). However, based on recent experience in some developing countries such as India and Nepal, many national/central forestry administrations have begun to find out that local participation becomes a

great deal more meaningful and effective where local populations are involved not as cooperating forest users but as forest managers and even owner-managers in their own right.

Empowering local communities as owner-managers of these forests by the national/central authorities through reform strategies that endow customary land interests with much improved status in state laws have also been noted to contribute to the success of these participatory processes. Several explanatory factors have been identified as influencing the success and/or failure of community-based management schemes (Agarwal, 2001; Dietz *et al.*, 2003; Pagdee *et al.*, 2006; Cavalcanti *et al.*, 2010). These explanatory factors (the relevance and importance of which vary between different places and times), can be attributed to characteristics of the resources systems, groups, institutional arrangements and external environment (Coulibaly-Lingani, 2011).
Central to achieving participatory forest management is the adoption of various policies and legal supports through series of reforms in National Forestry Policies, National Forest Management Plans and particularly Forestry Legislations and Land Reforms that support participatory approach in forest management (Wily, 1997; 2000; 2001). Furthermore, proper identification and definition of interests of parties to these participatory forest management systems early at their inception have been noted to contribute to their success. For instance, system of participatory (or joint) forest management that was commenced in the North West Frontier Province of Pakistan in 1996 through Asian Development Bank's funded project was largely unsuccessful (Ali *et al*., 2007).

This experience of unsuccessful outcomes from such project aimed at stakeholders participation in forest management in Pakistan was as a result of observed continuous large scale deforestation partly because the main priorities of the local people were financial and food security; whereas the North West Frontier Province of Pakistan model of joint forest management emphasised more on forest protection and regeneration (Ali *et al*., 2007). Devolution of forest management authority to local communities on one hand, provides a good opportunity to improve the living standards of the poor (Baumann, 2000) and on the other hand, it may lead to an increase in exploitation of resources in order to raise the incomes of local people (Baumann and Sinha, 2001).
It therefore suffice to say that any type of participatory approach to be implemented must be well conceptualised in such a way that challenges that may inhibit success are taken care of, at every necessary stage of the processes in order to avoid negative outcomes such as that in the case of North West Frontier Province of Pakistan, where the joint forest management approach enhanced the social assets of the local communities but omission of immediate financial benefits from the institutional changes in the forestry sector was a barrier in motivating the local people in forest protection and was one of the main issues hindering the effectiveness of the forest reforms process (Ali *et al*., 2007).

Lessons from some Participatory Resources Management Strategies

The recent trend concerning sustainable forest management is that there is the need to involve community, (either forest dwelling and/or those living within forest fringes), in the management of forests through participatory models. These models are diverse and location- or site-specific and are usually determined by various dynamics, anticipated or otherwise, influenced by local conditions, noting that the issue of power sharing is critical despite the broad consensus on the normative agenda of decentralisation, with lacunae still existing between local communities who depend on forests for livelihood and the state forestry agencies who seek to maximise state revenues from forests. Nevertheless, there are basic conditions, such as legal reforms, community consensus, equity, transparency and accountability that are vital for successful implementation of these models.
In general, for participatory approach towards forest management to be successful in developing countries, like those in West Africa, there must be real devolution of power to manage forests to local community and secure tenure rights of marginalised groups backed by appropriate and adequate legal framework and institutions consistent with the reality within which these forest management approaches are to be implemented. The implication of this is that there is the need to review and reform all existing forest policies, laws and administrative strategies to reflect the current paradigm shift towards these participatory models in the different countries. The importance of proper legal framework for the successful implementation of these models needs to be emphasised so that managing forests based on them do not lead to collapse midway.

For instance, in the case of Duru-Haitemba forest in Tanzania, community rules were challenged in the courts by a group of disgruntled cattle owners and then a group of outsiders annoyed at the closure of their felling operations. Owing to the fact that the participatory forest management plans and rules lacked the weight of law, the communities were not able to convince the District Magistrate. Another example is that of Muzama initiative in North Western Province, Zambia, that helped a number of local beekeeping and pit-sawing groups operating within a rich one million hectare area of miombo woodland to market their products internationally to considerable local benefit. However, in 1999 the Forest Department withdrew the groups' harvesting permits to open the area to commercial logging to raise its own revenue.

Perhaps, if the Muzama initiative had been founded upon legal framework to manage the woodland rather than agreement only to use it, then the dramatic loss of livelihoods may not have occurred in this instance. Furthermore, another issue that must also be taken cognisance of is the inherent weakness that accompanies relations of power, both within and between communities. One commonly raised criticism is the persistent failure of participatory approaches to successfully target marginalised and disadvantaged groups. Elite domination (elite capture), technocratic hegemony, gender discrimination and social exclusion have hindered the realisation of desired goals of such approaches in some communities. In addition, these approaches can both undermine local expertise, and may create false expectations if not properly conceived in an inclusive manner that carries along these marginalised and disadvantaged groups.

Proper arrangements, backed by appropriate legislations and laws, are to be made at the inception of these participatory management processes to prevent the strengthening of certain hierarchies in the society that are not in tandem with many needs on the ground that will benefit these communities, particularly the poor people. Thus, adequate wide consultation should be made within the communities in order to identify all groups that are necessary for successful participatory process, noting that some groups, such as agricultural settlers, loggers, investors, and people for whom forest loss is not a serious problem, or is even a positive benefit, may not even be interested in these processes. The formation of participatory forest management implementing bodies should not be complicated, bearing in mind that their legal personality should not be ambivalent avoiding vague or unnecessarily limited powers. It is also important to note that devolution of powers by national/central authority to the community level has implications for these communities to act. This is one of the reasons why properly and adequately conceived policies and laws are important to prevent, for instance, the community setting aside or 'reserving' an area meant for forestry for later use for settlement or agriculture. This might lead to conflict of interest which might be sorted out in law courts; thus, the importance of endowing collaborative or community-based forest management systems with legal force, which binds the community and the partnering institutions, to the management regime expressed in the law, becomes crucial. It is also common to find that many professional foresters in government employment exercise fear for their jobs and are sometimes sceptical towards successful implementation and outcome from these participatory forest management strategies.

Many of these foresters (and some that are not employed by government) argue that it is more risky releasing powers long held to be the domain of governments to communities, yet there is the emerging recognition that forests will not be secured without such democratisation. Nevertheless, managing these forests by community do not by any means mean the withdrawal of contributions from professional foresters to these schemes. Cooperation and support are needed from these communities in order to be able to procure the services of professional foresters. In addition, depending on the type of participatory forest management models, the roles of professional foresters in government employment might be to provide policy guidance, ensure policy compliance and quality control, offer training and capacity building, raise awareness, monitor and channel funds.

Furthermore, experience have shown that there are almost always challenges concerning institutional formation in countries where years of war or policies have resulted in marked population dislocation, with 'communities' often in reality an aggregation of disparate groups, each with their own loyalties and conflicting understanding of their resource rights and claims. This should not be unexpected in many of the West African countries, such as Liberia, Cote d'Ivoire, Togo, among others, that have experienced civil disturbance in the recent decades. Thus, adequate preparations in terms of well conceived laws, reforms and policy compliance are expected to take care of these kinds of situations.

Similarly, capacities for managing forests in participatory ways are also to be developed in different communities where there are overlaps of community forest boundaries. This is particularly important where these overlaps transcend national and international boundaries with the individual forest having different distinct management objective(s). Concerned communities and governments are expected to be acquainted with necessary skills in continuous dialogues that will ensure the prevention and/or proper management of conflict of interests as a result of possible these overlaps. It is also important that more be done concerning the definition and sharing of benefits from forests managed through participatory models in order for the practices to be successful and sustainable. Thus, conducting regular up-to-date forest inventories and writing of satisfactory management plans will help in this regard.

These are particularly important in many West African countries where there is hardly current forest resource inventory; including working management plan. This is a serious challenge facing sustainable forest management in these countries. Many of the participatory forest management models available in literature were actually supported at the inception by some international funding agencies and non-governmental organisations. This therefore brings to light the importance of many of these organisations in West Africa concerning their roles in contributing to the development, implementation and success of these models. The intervention of these bodies such as the various Forestry Associations in this region in increasing the awareness of all stakeholders is not only a necessary ingredient towards achieving success using the various models but they should also act as intermediary between government and these various communities.

CONCLUSION

The essence of this article has not only been to reinforce the need to adopt/adapt inclusiveness into the strategies of sustainable management of renewable natural resources in developing countries but also to be mindful that while incorporating these inclusive methods there are likely to be other challenges that may arise from it and/or as a result of other outcomes relating to this, since the process is driven by human institution. Thus, it is important, as canvassed in this article, to take cognisance of these possibilities in order to continuously maximise the benefit associated with participatory approaches while simultaneously minimising the negative outcomes/impacts.

REFERENCES

Agarwal, B. (2001): Participatory Exclusions, Community Forestry, and Gender: An Analysis for South Asia and a Conceptual Framework. *World Development*, 29(10): 1623–1648.

Agrawal, A. and Ribot, J.C. (1999): Accountability in Decentralization a Framework with South Asian and West African cases. *The Journal of Developing Areas*, 33(4): 473–502.

Ali, T., Ahmad, M., Shahbaz, B. and Suleri, A. (2007): Impact of Participatory Forest Management on Financial Assets of Rural Communities in Northwest Pakistan. *Ecological Economics*, 63(2): 588–593.

Amanor K.S. (2004): Natural and Cultural Assets and Participatory Forest Management in West Africa. University of Massachusetts' Amherst Political Economy Research Institute [PERI] *Working Paper Series* No. 75: 1-35.

Balooni, K. (2002): Participatory Forest Management in India – An Analysis of Policy Trends amid 'Management Change'. *Policy Trend Report*, 2002: 88 – 113.

Baumann, P. (2000): Sustainable Livelihoods and Political Capital: Arguments and Evidence from Decentralization and Natural Resource Management in India. ODI Working Paper, Vol. 136. Overseas Development Institute (ODI), London, UK.

Baumann, P. and Sinha, S. (2001): Linking Development with Democratic Process in India: Political Capital and Sustainable Livelihoods Analysis. ODI, Natural Resource Perspectives, Vol. 68. Overseas Development Institute, London, UK.

Bertrand, A. (1991): Les Problèmes Fonciers des Forêts Tropicales Africaines: Les Fonciers de l'arbre et les Fonciers Forestiers *Bois et Forêts des Tropiques*, 227: 11–16.

Bush, M. (2000): Learning by Doing in Co-Management for the Classified Forests of Guinea-Conakry. *CM News* No. 4 September 2000, Gland.

Cavalcanti, C., Schläpfer, F. and Schmid, B. (2010): Public Participation and Willingness to Cooperate in Common-Pool Resource Management: A field Experiment with Fishing Communities in Brazil. *Ecological Economics*, 69(3): 613–622.

Coulibaly-Lingani, P. (2011): Appraisal of the Participatory Forest Management Program in Southern Burkina Faso. Unpublished Doctoral Thesis at the Swedish University of Agricultural Sciences, Alnarp, Sweden. 96pp. ISSN 1652-6880; ISBN 978-91-576-7554-5.

Dietz, T., Ostrom, E. and Stern, P.C. (2003): The Struggles to Govern the Commons. *Science*, 302(5652): 1907–1912.

Djodjouwin, L. (2000): Participatory Management of Natural Resources in Benin: Case Study of the Bassila Subdistrict, Atacora District.

Forestry Association of Nigeria - FAN, (1989): History of Forestry in Nigeria. In: Okoro, O.O., Dada, G.O.B. and Akinsanmi, F.A. (Eds.) 100 years of Forestry in Nigeria. Pp. 2-6.

Foury, P. (1948): Principes de Sylviculture Tropicale. *Bois et Forêts des Tropiques*, 227–250.

Gambia German Forestry Project - GGFP, (2001): Guidelines on Publishing Gazette Notifications and Orders in the Context of Transferring Forest Ownership Rights from the State to Local Communities. Gambia German Forestry Project [GGFP], Banjul, The Gambia, January 2001.

Kerkhof, P. (2000): Local Forest Management in the Sahel: Towards a New Social Contract. Foley, G. (Ed.). Pp. 56. SOS Sahel International, London, UK.

Lorng, J-P. (2000): Participatory Management of Gazetted Forests in Cote D'Ivoire: The Experience of the Forest Development Society. In: Proceedings of the International Workshop on Community Forestry in Africa. *Participatory Forest Management: A Strategy for Sustainable Forest Management in Africa*, 26 - 30 April 1999, Banjul, the Gambia. FAO, Rome.

Montagne, P. and Mamoudou, H. (2000): Ten years of Implementing the Domestic Energy Strategy in the Niger. In: Proceedings of the International Workshop on Community Forestry in Africa. *Participatory Forest Management: A Strategy for Sustainable Forest Management in Africa*, 26 - 30 April 1999. Banjul, the Gambia. FAO, Rome.

Neef, A. (2003): Participatory Approaches under Scrutiny: Will they have a Future? Quarterly Journal of International Agriculture, 42(4): 489-497.

Onweluzo, B.S.K. (1988): Forestry Research and Development in Nigeria. *Obeche*, 22: 1–5.

Pagdee, A., Kim, Y.S. and Daugherty, P.J. (2006): What makes Community Forest Management Successful: A Meta-Study from Community Forests throughout the World. *Society & Natural Resources*, 19(1): 33–52.

Paudel, K., Green, K., Ojha, H. and Barnes, R. (2007): Challenges to Participation: Lessons from Participatory Action Research with Community User Groups in Nepal. *Journal of Forest and Livelihood*, 6(1): 70 – 78.

Peluso, N.L. (1992): *Rich Forests, Poor People: Resource Control and Resistance in Java.* Berkeley: University of California Press. 336pp. ISBN: 9780520089310.

République de Côte d'Ivoire, (1949): Arrêté N°1762 S.F.CH du 3O Décembre 1948 fixant certaines conditions d'application du Décret du 4 Juillet 1935 sur le régime forestier et réglementant l'exploitation et la circulation des produits forestier sur le territoire de la Haute Volta. *Journal Officiel de la Côte d'Ivoire*, Février 1949: 86–92.

Saarela-Kaonga, T. (2001): Community Forestry in Cross River State of Nigeria. Lessons Learnt and the Way Forward. Living Earth Foundation, Nigeria.

Westoby, J. (1987): *The Purpose of Forests: Follies of Development.* Oxford: Blackwell.

Wily, A.L. (1997): Villagers as Forest Managers and Governments 'Learning to Let Go': The Case of Duru-Haitemba and Mgori Forests in Tanzania. *Forest Participation Series No. 9.* IIED, London.

Wily, A.L. (2000): The Evolution of Community-Based Forest Management in Tanzania. In: *Participatory Forest Management. A Strategy for Sustainable Forest Management in Africa.* Proceedings of the International Workshop on Community Forestry in Africa. 26–30 April, 1999, Banjul, The Gambia. Food and Agriculture Organization, Rome.

Wily, A.L. (2001): Forest Management and Democracy in East and Southern Africa: Lessons from Tanzania. *Gatekeeper Series No. SA95*: 1–20.

Wily, A.L. and Hammond D. (2001): Land Security and the Poor in Ghana. Is There a Way Forward. A Land Sector Scoping Study. DFID Rural Livelihoods Programme, Accra.

World Bank, (1978): Forestry: *Sector Policy Paper Report No*. 11021.Washington, DC.

Socio-economic Analysis of Walnut fruit (*Tetracarpidium conophorum*) in Iwo Local Government, Osun State, Nigeria

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ABSTRACT

This paper examines the profitability of Tetracarpidium conophorum (walnuts) in Iwo Local government Osun State Nigeria. Primary data was collected using one hundred structure questionnaire administered to walnut marketers. The result revealed that the Gross Income (GI) is ₦1,304.16, Net Income (NI), ₦ 15,528,16 and Rate of Return (RORI), ₦532.42. the cost and returns Analysis revealed that the business is profitable. It is recommended that the government should form a commodity board that will readily purchase sellers' produce at minimum prices.

Key words: *Tetracarpidium conophorum*, profitability, rate of return

INTRODUCTION

The Nigerian Black walnut botany known as *Tetracarpidium conophorum* (Animashaun, 1994). The common variety is known as *Plukenetia conophorun* (Gbile and Soladoye, 2002). Black walnut also called eastern black walnut and American walnut. (Robert1977). Walnut is one of the scarcest and most coveted native hard woods. Small natural groves frequently found in mixed forest on moist alluvial soil have been heavily logged. The fine straight grained made prize pieces of solid furniture and gunstocks. As the supply diminishes, the remaining quality black walnut is used primarily for veneer. The distinctive tasting nuts are in demand for baked goods and ice cream, but people must be quick to harvest them before the squirrels eats them up. The shells are used for many products (Williams 1979). Walnut first selected for nuts production has been propagated since 1881 and still dominated by local varieties, since that time over 750 cultures have been selected and manned (Funk 1979). Substantial plant breeding programmes have resulted in availability of a large number of hybrid cultivars. However, there cultivation has been mainly confined to USDA plant hardinedd zone 4 through 8 (Weber, 1980). Flowering and fruiting Depending on latitude, black walnut flowers generally begin to appear about mid April in the south and progressively later until early June in the Northern of the natural range. Flowering and fruiting out occur at approximately the same time and always early enough for possible damage by late spring frosts.

Walnut is monoecious; male flowers, which are slender catkins, develop from auxiliary buds on the previous year's outer nodes, while female flowers occur in short terminal spikes, ranging from a few to many home on the current years shoots. Flowering is dichogamous and protogyny (the female flowers appearing first) more common than protandry (male flowers appearing first). Because of its dichogamous flowering habit, self-pollination is unlikely. However, individual trees usually are not self- sterile; if they are not pollinated by neighbouring tress, they may set self fertilized seeds. Fertilization follows 2 to 3 days after pollination. Succeeded by development of the husk, the shell and finally by the seeds itself (Funk, 1979). Mature black walnut on good sites may reach 30m to 37m(100 to 120ft) in height and 76 to 102 cm (30 to 40in) in d.b.h. Trees 40m (130ft) tall and more than 244cm (96in) in d.b.h have been reported in Wisconsm in Indiana, black walnut trees were 46m (150ft) tall and 183cm (72in) in d.b.h on the most favorable sites. Research and experience indicate that with proper care it may be possible to Produce 41cm (16in) saw logs in 30 to 35 years, and by planting on a good sites it may be possible to produce 51cm (20in) veneer logs in 40 to 50 years. By applying some basic cultural practices, such as release and pruning, to establish trees, growth and quality can be greatly increased in only a few years. Black walnut growth increased when interplanted with nitrogen fixing shrubs and trees. (Clark, 1979). According to Faleyimu *et al* (2010), the plant can be used for the treatment of diarrhea, stomach upset, loss of appetite, indigestion, excessive heat in the womb, itching, open wound, eczema, ring worm and diabetes.

METHODOLOGY

The Study Area

The study area was conducted was Iwo Local Government Area of Osun State. The study area occupies major position in the agriculture economy of Nigeria and in the southern part of the state. The state has a population of 2,303,900 people according to 1991 census (FOS, 1994). The state is located between latitude 7^0N and 30^0N and longitude 4^020'E and 4^050^iE of the prime meridian. It shares common borders with Kwara in the North-West and two other state Namely, Oyo in South West and Ekiti in the South East. The climate varies from North to South of the State. Iwo L.G.A is reputed to be considered as the food basket of Osun State. The local government is located at the western part of Osun State. The major town is Ede, Ejigbo, Ife, and Odo-oba. (www.osunstategov,ng.downloadbankable,20feasibilityof20studies).

Data Collection and Source

Primary data was used for this study; the primary data were collected using well structured set of questionnaire to assess the profitability of the walnut.

The Sampling Techniques

A total of 100 marketers were purposively selected for the study. Ninety five percent of the questionnaire were retrieved.

Analytical Techniques

The following tools of analysis were employed to achieve the profitability of the business.

1. Descriptive statistic
2. Marketing efficiency
3. Farm budgeting techniques
4. Z-Test

Marketing Efficiency

To determine profitability of the business the following tools were used:
Net income (NI)
Net income (NI) is defined as total revenue (TR) less total cost (TC), mathematically

$$NI=TR - TC$$

Where:

NI = Net Income
TR = Total quantity of product sold in a ……..X Unit selling price
TC = total quantity sold in a ……..X unit product or purchase

b. Gross Ratio (GR)
This is the total Expenses or Total Cost (TC) divided by total revenue (TR) give as:

$$GR=\frac{TC}{TR}$$

The ratio shows the percentage or proportion of total physical cost that constitutes the Total Revenue. A Gross Ratio of less 1.0 ratio is desirable for any productions business. The lower Gross Ratio, the higher the return per naira invested. The total cost and the total revenues values calculated above are applied in the equation for the determination of the Gross Ratio.

c. Rate of Return: ROR $=\frac{TR\,x\,100}{TC}$

d. Rate of Return on investment (RORI)

The RORI depicts the level of profitability of an investment and is an important criterion in determines the choice of investment.

$$RORI=\frac{TR-TC}{TC} \times \frac{100}{1}$$

Farm Budgeting Technique

a. Gross Margin Analysis

Gross margin (GM) is defined as total revenue (TR) less total Marginal cost (TMC) (Olukosi *et al*, 2005)

$$GM=TR - TMC$$

GM = Gross Margin
TR = Total Revenue
TMC = Total Marketing Cost

z-test (specification for Hypothesis Testing)
Z-test was conducted to confirmed hypothesis: walnut production in Iwo Local Government Area is not profitable
The formula for the Z-test is given as

$$Z= R-Z-C/\sqrt{R^2 /N_1 + C^2/N_2}$$

Z = the 'calculated Z value
R = Mean of marketers return (N)
C = Means of Marketers cost
R^2 = Variance of Return (N)
C^2 = Variance of cost
N_1 and N_2 = sample sizes association with marketers and cost

RESULTS AND DISCUSSION

Majority of the marketers are under the age of 41-50 years representing 54.7% as shown in table 1. Most marketers in the area are adults. Few marketers are under 61-70 years (2.11%). Tables 2 revealed that majority of the sellers in the area are males (60%). This indicated the farmers producing walnuts are also involved in selling walnut. Table 3 showed that majority of the marketers are married and this represent 89.47% while 10.52% are single. Most of the marketers have been selling walnut for over 1-10 years representing the highest percentage 56.8% (Table 4). Marketers who have been selling the crop for 11-20 years represent 43.2%. Most marketers in the area are adults and spend a good number of years selling the crops. Majority of the sellers in the area are educated (literate) this represents 83.2% of the total marketers as shown in table 5. This indicates that the farmers in the area will be able to adopt innovations and improved technology. Table 6 indicated that the majority of the marketers (48.4%) in the area source their capital from friends and personal saving (48.4%) while 3.2% of the marketers use capital source from cooperatives. The Z-test revealed that the tabulated Z (0.0596) is greater than the calculated Z(0.00008). HO is accepted while HI is rejected. This implies that the claim between profitable and not profitable is legitimate at 0.05 significant level and even at 0.01 significance level. The cost and return Analysis revealed that the business is profitable.

Table 1: Age distribution of Marketers

Age	Frequency	Percentage
21-30	3	3.16
31-40	38	40.0
41-50	52	54.7
51-60	0	0
61-50	2	2.11
Total	**95**	**100**

Table 2: Genders

Age	**Frequency**	**Percentage**
Male	57	60
Female	38	40
Total	95	100.0

Table 3: Married Status Distribution

Age	**Frequency**	**Percentage**
Married	85	89.47
Single	10	10.52
Total	95	100.00

Table 4: Experience in selling walnut

Age	Frequency	Percentage
1-10	54	56.8
11-20	41	43.2
21-30	0	0
31-40	0	0
Total	95	100.00

Table 5: Distribution Education Background of the Sellers

Education	Frequency	Percentage
Non-formal education	11	11.8
Primary education	79	83.2
Post primary	5	5.2
Total	95	100.00

Table 6: Sources of Capital (finance) to the marketers

Source of capital	Frequency	Percentage
Friends	46	48.4
Personal savings	46	48.4
Cooperatives	3	3.2
Total	95	100.00

Gross Margin Analysis

The various costs incurred and the revenues obtained were estimated based on the prevailing market price as at the period of survey. Since sampled traders were small scale, their fixed cost was negligible so only the variable cost gave an average value of ₦6465.95 per months of marketing. The gross income estimated gives an average value to ₦13084.37.

Table 7: Gross Margin Analysis of sampled Traders

Item	Estimated value (N)
Gross income	13084.37
Purchase cost	2443.74
Fees to commission	357.30
Storage cost	2320.00

Transport cost	952.80
Handling cost	412.11
Net income	6598.42

Marketing Efficiency

Marketing efficiency here refer to the extent at which the financial returns are capable of off-setting costs. Three basic economic tools for measuring efficiency are employed. There are; Net Income (NI), Gross Ratio (GR) and Rate of return to Investment (RORI).

NI, GR and RORI Analysis

The analysis showed that TR=Total quantity of product sold and its corresponding unit selling price produced. Similarly TC is, the product of total quantity purchase by the producers' unit cost and the marketing costs. The difference between TR and TC gave Net Income (NI) which measure the level of profit generated from a business. Table 8, revealed that marketer went home with Net Income of ₦1,3084.37, based on the magnitude of NI, this means marketing is efficient. The RORI is higher than GR. The lower values in the GR indicated that the business is profitable because the higher the GR the worse the business. RORI measures profit level. GR is the best instrument for measuring efficiency of a business, since it measures the expenses of a business.

Table 8: Cost and Returns Analysis in Marketing of Nigeria black walnut product

Market location	**Gross Income (GI) Mean Value**	**Gross cost (N) GC Mean Value**	**Net Income NI**	**Rate of Return (RORI) Investment**	**Gross ratio GR**
IWO L.G	₦ 15528.11	₦ 2443.74	₦ 13084.37	₦ 535.42	0.157375

1. Farm Budgeting Technique
   a. Gross margin (GM)
   GM = TR -TMC
   GM = 15528.11 - 6485.95
   GM = 9042.16

2. Z-Test (specification for hypothesis testing)
   Z-test was conducted to confirmed hypothesis: Black walnut marketing in Iwo Local Government Area is not profitable

Where	Z	=	The calculated Z Value
	R	=	Mean of marketers Return = ₦ 15528.11
	C	=	Mean of marketers cost of commodity = ₦ 2443.74
	R^2	=	variance of return = 50124594.305
	C^2	=	variance of cost = 159.604
	N_1 and N_2	=	sample size associated with marketers return and cost = 96
	Z calculated	=	0.00008
	Z tabulated	=	0.0596 Therefore, Z tab>Z-cal

CONCLUSION AND RECOMMENDATION

Income realized by the marketers is used in educating their children, building of houses and other basic things of life. The cost and return analysis revealed that the business is highly profitable. For increase return on black walnut marketing, there is need for the formation of commodity board that will readily purchase sellers produce at minimum prices. There is also the need for provision of storage facilities to reduce storage losses.

REFERENCES

Animashahun O. (1994): Characterization of isolation of *Tetracarpidium conophorum* seed. VolV1. 299-303. http://www.ncbi.nim.gov/sites/enter?cm

Clark J. (1979): Black walnut growth increased when interplant with nitrogen fixing shrubs and trees. *Indian Academy of science proceedings* 88-91. http://www.nicb.nim.nih/gov/sites/emd.

Gbile Z.O, Soladoye M.O (2003):Vernacular names of Nigerian plants (Yourba). Volume 2. Published by FRIN. Pp 101

Faleyimu, O.I, Ishola I.A and Akinyemi , O (2010): Medicinal uses of *Tetracarpidium conophorum. Proceedings of the 33rd Annual Conference of the Forestry Association of Nigeria. Held in Benin City Edo State Nigeria.* Pp123 127

Funk D.T(1979): Black walnuts for nuts and timber in nut tree culture in Northern America. Northern growers Association. Pp51-73

Olukosi A (2005): Introduction to agricultural marketing and prices . principles and applications. Living book publishers, Abuja. 200pp

Webber H. (1980): How to diagnose black walnut damage . USDA forest service . general technical reports. 20pp

Assessment of Charcoal Marketing in Oyo state, Nigeria

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ABSTRACT

Charcoal is an important source of domestic energy which also plays vital roles in providing livelihood for most households in rural and urban areas of Nigeria. The economic analysis of charcoal marketing in selected markets, Oyo State, Nigeria was investigated with a view to determining its profitability, market structure and conduct as well as the constraints encountered by the marketers in the business. Data for the study were obtained from a total sample of 54 randomly selected respondents through administration of structured questionnaires and personal interview. The data were analyzed using budgetary technique and Gini-Coefficient. The results indicated that the total revenue and gross margin were ₦6,201,500 and ₦ 1,370,269 while the revenue and gross margin per marketer were ₦ 114,842.59 and ₦ 25,375.35, respectively. The results also revealed that the Benefit-Cost ratio was 1.28 indicating that an investment of ₦100 in the business will yield ₦28.00 implying that charcoal business is profitable. The findings showed that government policy is a major constraint to charcoal business in the study area. It is therefore, recommended that government should review the forest policy that deals with charcoal production and marketing. This is necessary so that there will be a balance between government protection of the environment and the activities of charcoal marketers.

Keywords: Charcoal, market structure, profitability, tree plantation and environmental sustainability

INTRODUCTION

Charcoal is the blackish residue consisting of impure carbon obtained by removing water and other volatile constituents from animals and vegetation substances. Charcoal is usually produced by slow pyrolysis, the heating of wood, sugar, bone char, or other substance in the absence of oxygen. Charcoal is probably a more efficient cooking fuel than wood (NRI, 1992). The reason is because 50% energy loss associated with the production of charcoal from wood is more than compensated by the much higher fuel efficiencies obtained in burning charcoal as cooking fuel. (Kalu and Izekor, 2007). Wood charcoal is in high demand in different parts of the world especially Africa (figure 1). Charcoal production is an important source of revenue for Nigeria and it is reflected by the fact that the country ranks among the highest producer of charcoal in the world. According to FAOSTAT (2015), Nigeria, ranks second in charcoal production in the world (figure 2). Wood charcoal of Nigeria was reported to be one of the best in the world and highly sought after.

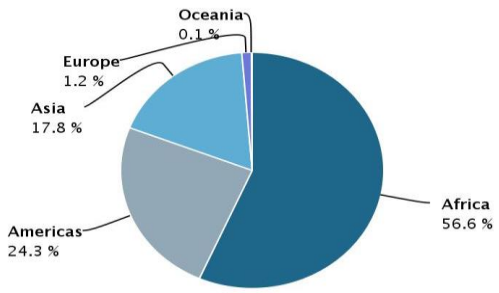


Figure1: Share of charcoal production by region. Source: FAOSTAT (2015)

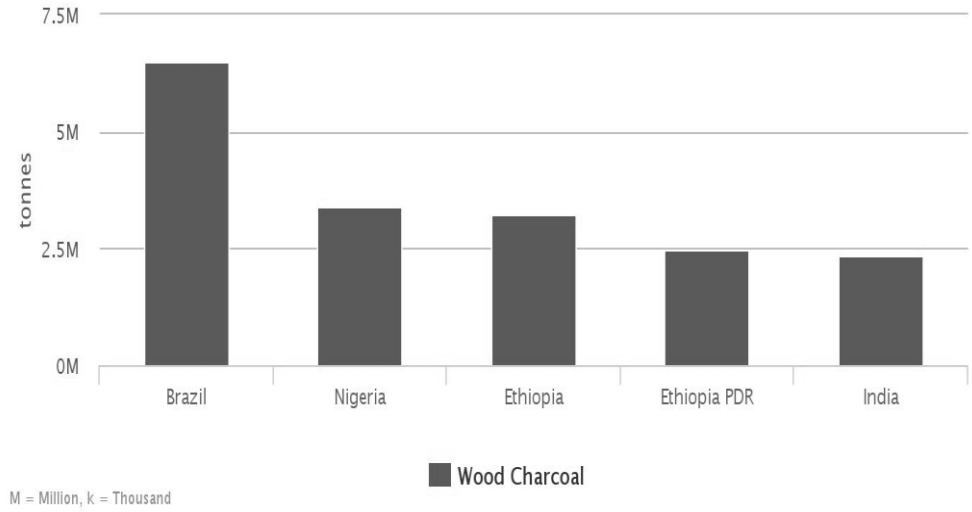


Figure 2: Charcoal production in Africa Source: FAOSTAT (2015)

Charcoal briquettes are widely used for outdoor grilling and barbecue in backyards and on camping trips. In many developing countries, charcoal is used for everyday cooking by large proportion of the population. Charcoal stove has fuel efficiencies of 25-35% whereas wood stove is about 10% efficient (Bulaghsingala, 1983). Charcoal remains the most important source of energy for domestic and small scale commercial processing as well as food preparation especially in roasting maize, plantation, yam, and meat. This is a regular feature in most streets and some eating joints and restaurants in Nigerian cities (Kalu and Izekor, 2007). As important as charcoal is in developing economies, most investors are still skeptical about its prospect since they are not sure if marketing of charcoal will yield good returns on their investments. This therefore brought about the following research problem statement:

(1) Is marketing of charcoal actually profitable in the study area?
(2) What are the structures of charcoal market in the study area?
(3) What factors serve as constraints to the profitability of charcoal in the study area?

As unemployment continues to be a challenge for most Nigerian populace and investors are now looking into the charcoal industry, this study will therefore enlighten the investors as it will enable them to know if the business is actually profitable or not, it will also enable them to know the features of charcoal market and the constraints they are likely to encounter in the business. This study is intended to fill the knowledge gap in charcoal business research especially in the study area. The paper specifically assesses (1) the profitability of charcoal market (2) the market structure and conduct of charcoal and (3) the constraints to charcoal profitability.

METHODOLOGY

The study area of the research is Bodija market which is located in the Ibadan North Local Government area of Oyo State, Nigeria. It is about one kilometer from the University of Ibadan, Ibadn, Nigeria along the road to the State Government's Secretariat which is also about one kilometer away. It is the main recipient and distributor of all goods (which range from forest products to agricultural products as well as industrial goods) that moved from different parts of the country to Ibadan metropolis and some parts of the Yoruba south west. Bodija market is also one of the largest food markets in Nigeria. It is composed of thousands of independent sellers who compete for sales (Filani, 2005). All major food items are sold in different sections and there are also sections for charcoal marketers while other non timber forest products such as fuel wood, palm-kernel and so on scattered through-out the market. The market serves as an important meeting point for both buyers and sellers in south west Nigeria and this makes it suitable as the study area. Data for the study were obtained from a total sample of 54 randomly selected respondents through interviews schedules, application of structured questionnaires and personal observations.

DATA ANALYSIS

Data were analyzed using budgetary technique and Gini-Coefficient. The Gini- Coefficient was used to examine the market structure while budgetary technique was used to determine the profitability of charcoal marketing enterprise. Benefit-Cost Ratio was also calculated to determine the rate of return on investment in the business. The gross margin was estimated as the difference between total revenue and total variable cost incurred in marketing charcoal as stated in equation (1)

G.M = T R – T V C……(1)

Where

G .M = Gross margin (₦) per month.

T. R = Total revenue (₦) per month

T V C = Total Variable Cost

Benefit- Cost Ratio was estimated as the ratio between total revenue and total variable cost.

RESULTS AND DISCUSSION

Market Structure and Conduct of Charcoal Business

The results in table 1 showed that cost of acquisition is the major factor that determine price of charcoal in the market. This revealed that whenever there is increase in cost of acquisition, the marketers will adjust to it by increasing the price or decreasing the size of each unit sales. The result also revealed that forces of demand and supply also influence the sales price of charcoal. This follows the laws of demand and supply which states that the higher the price, the lower the quantity demanded and *vice versa.* This follows from the first result that whenever the acquisition cost increases, the marketers will adjust to it by increasing the selling price, when this happens, the buyers too will react to the market by shifting to other fuel such as firewood, kerosene, gas and others or lower the quantity of charcoal purchased per time. The result also revealed that quality of charcoal influences the price of the charcoal. Charcoal with high quality especially those that are noiseless, smokeless and last while in-use usually command higher price while types commands low price. The quantity of charcoal in the market also influences the price of charcoal. Though it is rare to have glut in charcoal market yet when there is excess charcoal in the market, the retailers tends to increase the size of each bundle per sales. The ability of the buyers to bargain has no effect on the price since there is no price discrimination in charcoal market. The findings also indicated that open display method (55.6%) is the major way of attracting customers; this was followed by persuasive effort at retail level (24.1%), quality product (13.0%) and giving of extra quantity as substitute for discounted price (7.40%). This showed that there is no rigorous advertisement for charcoal market in the area. The marketers (81.5%) agreed that there are differences in the types of charcoal sold in the market. The difference is based on the type of trees/ wood from which it was produced. There is a functional charcoal association which any charcoal marketer must belong if they are to remain in the business. This suggests that there is no free entry but exists in the business.

The analysis of sellers' concentration for charcoal showed that the computed Gini-coefficient was 0.67. This showed that the market was not concentrated hence, the possibility of high competitive behavior and inequality in earnings among the marketers. Variation in earning from charcoal is high as various charcoal market institutions are disposed to different risks. This confirms Iheanacho (2005) who stated that inequality in earning is a partial reflection of differences in the risk of investment. It also agrees with Olukosi (2005) who stated that people differ in their risk preference and this affects their earning. Those with a higher propensity to take risk tend to choose more risky ventures and as a result, could have higher earnings and thus make more profits. Conversely, people with a relatively high degree of risk aversion seem to prefer less risky and less profitable investment and consequently, obtain lower earning. When asked if the respondents own any tree plantation establishment as a source of raw materials for charcoal production, majority of them (99%) reported they did not have tree plantation, which implies they possibly source for charcoal from illegal tree fellers. However, majority of the respondents (83.3) indicated their willingness to establish a tree plantation for charcoal production, if given the enabling environment and technical assistance.

Table 1: Market Structure and Conduct of Charcoal

Characteristics	Frequency	%
Price determination		
Forces of demand and supply	15	27.8
Cost of acquisition	24	44.4
Quality of product	8	14.8
Quantity of charcoal in the market	7	13.0
Ability of buyers to bargain	0	0.0
Total	54	100.0
Methods of attracting customers		
Open display	30	55.6
Persuasive effort	13	24.1
Quality product	7	13.0
Discount price/ extra	4	7.4
Total	54	100.0
Differences in the Charcoal sold in the market		
Yes	44	81.5
No	10	18.5
Total	54	100.0

Existence of charcoal Association.		
Yes	53	98.1
No	01	1.9
Total	54	100.0
Membership of the association		
Yes	53	98.1
No	1	1.9
Total	54	100.0
Can someone engage in the business Without being a member of the association?		
Yes	11	20.4
No	43	79.6
Total	54	100.0
Market concentration		
Gini coefficient	0.67	
Environmental sustainability and charcoal production		
Own tree plantation		
Yes	1	1.0
No	53	99.0
Willing to plant trees?		
Yes	45	83.3
No	9	16.7

Source: Field survey, 2013

PROFITABILITY ANALYSIS OF CHARCOAL MARKETING

The result in Table 1 revealed that acquisition cost accounted for 59.78% of the total sales revenue while cost of transportation accounted for 11.01% of the sales revenue. The cost of labour gulped 6.06%, association levy also accounted for 0.04% and cost of storage was 1.02% of the total sales revenue. The table also showed that acquisition cost accounted for 76.73% of the total cost while cost of transportation accounted for 14.14% of the total cost. The cost of labour was 7.77% of the total cost while storage cost accounted for 1.31% of the total cost. The association levy accounted for 0.050% of the total cost. The low storage cost among the marketers may be due to the fact that most of them, particularly the retailers sell their charcoal in open spaces, along the road where stall are allocated and in front of their houses. The processors and wholesalers serve more as distributor and therefore need little storage facilities since there are ready buyers waiting for them to supply the products. The findings also revealed that an average marketer incurred a total variable cost of ₦ 91,155.30 per month but earned average revenue of ₦ 117,009.43 per month. This indicates that an average marketer earns ₦ 25,854 as gross margin per month suggesting that charcoal marketing is a profitable business in the study area. Moreover, result also revealed that Benefit-Cost ratio is 1.28 which indicated that for every ₦100 invested in the business, the marketer makes a return of ₦ 28.00. This shows that charcoal business is profitable and the result confirms Kalu and Izekor, (2007) who stated that marketing charcoal is profitable at all levels of the marketing chains.

Table 2: Profitability of charcoal marketing

Items	*Amount (N)*	*% of TC*	*% of Total Sales*
Acquisition cost	3,707,000	76.73	59.78
Transportation cost	683,000	14.14	11.01
Storage cost	63,200	1.31	1.02
Cost of labor	375,601	7.77	6.06
Association levy	2,430	0.05	0.04
Total Variable Cost (TVC)	4,831,231		77.90
Total Revenue (TR)	6,201,500		
Gross Margin (GM)	1,370,269		
Total Variable cost per seller	89,467.24		
Total Revenue per seller	114,842.59		
Gross Margin per seller	25,375.35		
Benefit-Cost Ratio	1.28		

Source: Field survey, 2013

CONSTRAINTS TO CHARCOAL MARKETING

The result in Table 3 revealed that government forest policy is the main constraint to charcoal business in the study area. Most marketers complained that as profitable as the business is, government still considers it as a dirty and environmentally risky business. Government complained that cutting trees and burning them for charcoal are threats to environmental sustainability. Though government is much aware of the business, its association and also supports it to an extent yet, government is neither committed nor ready to implement the policy. The result also revealed that transportation and season of the year have the same effects in influencing charcoal market. This agree with the result in table 1 where cost of transportation ranks second to the highest cost (acquisition cost). This suggests that most marketers find it difficult to transport their goods from the farm gate to the buyers. While season especially raining season negatively affect the availability of charcoal; though the few ones available will then command high price. Capital set up is not a real constraint since marketers can start the business with as little as possible; while market instability is the least constraint since there are ready buyers once the location is good for sales.

Table 3: Constraints to charcoal marketing

Constraints	Frequency	Percentage
Transportation	11	20.4
Season	12	22.2
Government policy	22	40.7
Market instability	2	3.7
Capital set up	7	13.0
Total	54	100.0

Source: Field survey, 2013

CONCLUSION AND RECOMMENDATION

Marketing charcoal is a profitable business. Apart from its role as domestic source of energy, it also has significant potential of providing reliable income for rural households and other forest dependent people in the area. The results of the total revenue and gross margin per month indicate that charcoal business is profitable in the study area. The high Benefit-Cost ratio indicates that investment in charcoal business will yield a higher return. There is high inequality of income among the marketers as the findings show high Gini-coefficient. This suggests that, charcoal business is competitive in the area and profitable returns are distributed between a limited numbers of sellers. Despite the competition among the marketers, the major constraint to charcoal profitability was government policy and season of the year. It is therefore recommended that government should review her forest policy that deals with charcoal production and marketing. The findings from the study indicate that charcoal marketers are willing to establish their own tree plantation.

It is therefore, recommended that incentives to encourage charcoal marketers to establish tree plantation of their own should be put in place. This can be in form of training, subsidies on tree seedlings and strengthening of charcoal producers association. This is necessary so that there will be a balance between government protection of the environment and the activities of charcoal marketers.

REFERENCES

Bulaghsingala, S.S. (1983). Charcoal: An alternative renewable energy Source in the 1990s and beyond. In *Proceedings of Regional Symposium*. Association of Franco-Ceylonese technologists and French Technical Association, Colombia, Srilanka.

FAOSTAT (2015). Charcoal Production Statisics. Food and Agriculture Organization. Rome, Italy.

Filani M.O. (2005). Transport Market Study. The Bodija Cattle Market in Ibadan. Paper presented at Department for International Development, United Kingdom.

Ihenanacho A.C (2005). Structural Characteristics and Performance of Retail Marketing of Eggs in Maiduguri Metropolis of Borno State. *Nigeria Journal of Sustainable Development* 1:70-76.

Kalu C and Izeko, D.N. (2007). Charcoal Enterprise in Benin City, Edo State, Nigeria. *J. Appl. Sci. Environ. Manag*. 11(3): 63-67.

NRI Natural Research Institute (1992). Wood carbonization Unit; Design and development of prototype with recovery of waste heat, Chatham Main time, Kent, United Kingdom, Pp.20.

Olukosi J.O., Isitor S.U and Ode M.O. (2005). Introduction to Agricultural Marketing and prices: Principles and Application. Living Books Series, G.U. Publications, Abuja, Nigeria

Assessment of Undergrowth Plant Diversity in three different Vegetation at Gambari Forest Reserve, Oyo State, Nigeria

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ABSTRACT

The preservation of forest reserves in nigeria was aimed at protecting the God given plant diversity. Unfortunately, the area and component of the reserves are drastically reducing in quantity and quality due to human distructive activities on the ecosystem occasioned by population increase. Agroforestry would be a genuine means of recovering the lost diversity, this study therefore studied the possibility of agroforestry in conserving the remaining plant diversity in forest reserve. This study was carried out in Gambari forest reserve located at Oluyole Local Government area of Oyo state. Plant species sampling was conducted in a natural forest (NF) and Two Taungya agroforestry practices; Tangya Agforestry with Teak (TAT) and Tangya Agforestry with Obeche (TAO). Data were collected by randomly establishing sample plots within the sites. Tree species identification, classification and enumeration were executed. Data were analysed for diversity and similarity indices as well as the analysis of variance. A total number of 53, 39 and 29 individual plant species were respectively encounterd in the NF, TAO and TAT. Result shows that diversity of plant in the NF (3.49) was significantly higher than the diversity in TAT (2.10) but not significantly different from diversity in TAO. The similarity between the NF and TAO (47.2%) was considerably higher than NF and TAT (28.3%). Due to similarity between the natural forest and Taungya agroforestry with Obeche occasioned by the plant diversity, Agroforestry would have the potential of salvaging the threatened species majorly found in the natural forests.

Keywords: Undergrowth plant, vegetation, agroforestry, conservation

INTRODUCTION

Nigeria is blessed with quite a number of forest reserves but majority of these reserves are rapidly diminishing in diversity. Some indigenous practices were adopted in bid to conserve natural forest, some of which include giving of name that relate to "do-not-touch". Example of such names include "*Oso*" meaning "wizard" in Yoruba, "*Ani* mmo in" meaning "*Idol*" in Ibo language, Strict Nature Reserve, Biosphere Reserve, among others. One of the arguments in support of these names is to regulate extraction of forest products, as well as prevent their over-exploitation or total destruction. In addition to these indigenous measures, there are also government policy and legislation which are instituted to prevent illegal exploitation and regulate exploitation of forest resources.

Despite the preventive and regulatory measures, there still exist frequent cases of illegal logging and poaching activities in forest reserves (Udofia *et al.*, 2011). These activities have led to deforestation and forest degradation thereby detrimental to the recruitment and regeneration of indigenous tree species and other forest biodiversity (Adekunle *et al.*, 2002; Olajide *et al.*, 2008; Etigale, 2010; Udofia *et al.*, 2011; Udoakpan, *et al.*, 2013). In addition, vast areas of forest are being converted into plantation of exotic tree species, due to the believed that they grow faster than the indigenous species (Udofia *et al.*, 2011; Onefeli and Adesoye, 2014). With the current rate of deforestation in the country, couple with replacement of indigenous tree species, there may not be enough natural forest to conserve timber and non-timber need of the present and future generation. There is therefore the need for an alternative option through which our indigenous tree and other plant diversity could be conserved. Interestingly, agroforestry systems would be a promising alternative in this regard.

Agroforestry is a multiple land-use system in which agricultural crops and woody perennials are grown on the same land (Nair, 1993). *Taungya* practice is a form of agroforestry system and has been adopted in different part of the world for plantation establishment (Nair, 1993). It is known by different names including: *Tumpangsari* in Indonesia; *Kaingining* in the Philippines; *Ladang* in Malaysia; *Chena* in Sri Lanka; *Kumri, Jhooming, Ponam, Taila,* and *Tuckle* in different parts of India; *Shamba* in East Africa; *Parcelero* in Puerto Rico; *Consorciarcao* in Brazil and so on (King, 1968). Most of the forest plantations established in the tropical world, particularly in Asia and Africa, owe their origin to the *Taungya* system (King, 1979). According to Roche (1993), it is one of the cheapest landuse systems, capable of concomitantly yielding both wood and food while at the same time conserving and rehabilitating ecosystems.

Basically, *Taungya* system consists of growing annual agricultural crops along with the forestry species during the early years of establishment of the forestry plantation. The dominant philosophy of the *Taungya* system is that, forest plantation lands are allocated to unemployed or landless farmers, who are allowed to produce their crops within the plantation at the early age of the plantation. The farmers tend the trees and, in return, retain a part or all of the agricultural produce. It is very important to understand that biodiversity conservation is not the goal of *Taungya* system as well as other agroforestry practices (Nair, 1993; Brent and Jean-Marc, 2005). However, with the present wide range of involvement of farmers in the system vis-à-vis depletion of the natural forest, it becomes pertinent to investigate the extent to which the system can address the problem of loss of biodiversity. Hence, this study was conducted to compare the capability of *Taungya* used to establish two different plantation species (Teak and Obeche) with natural forest as control in the Gambari Forest Reserve. The agricultural crops cultivated with the tree plantings are cassava, yam and maize. The aim of this study therefore is to determine the potential of the system in recruiting and conserving flora biological diversity.

METHODOLOGY

Study Area

The study was conducted in Onigambari Forest Reserve located in Oluyole Local Government Area (LGA) of Oyo State. It is one of the early forest reserves in the state and it is divided into 5 series namely Onigambari, Busogboro, Onipe, Olonde and Mamu (Figure 1). The reserve is located between latitude 7^{o} 25'N and longitude 3^{o} 50'E. It is situated at the southern part of Ibadan bounded on the west by River Ona and on the east by the Ibadan-Ijebu-Ode road. The reserve is bounded by Abanla and Odoona settlements in Oluyole local government area of Oyo State in the north and in the south by Mamu and Abatan settlements in Ijebu-Ode local government area of Ogun State. Both dry and wet seasons are experienced in the reserve. Dry season lasts for three months (December - February). The average annual rainfall is about 1140mm and average annual temperature is about 26.4^{o}C-80^{0}F (Roche,1993).

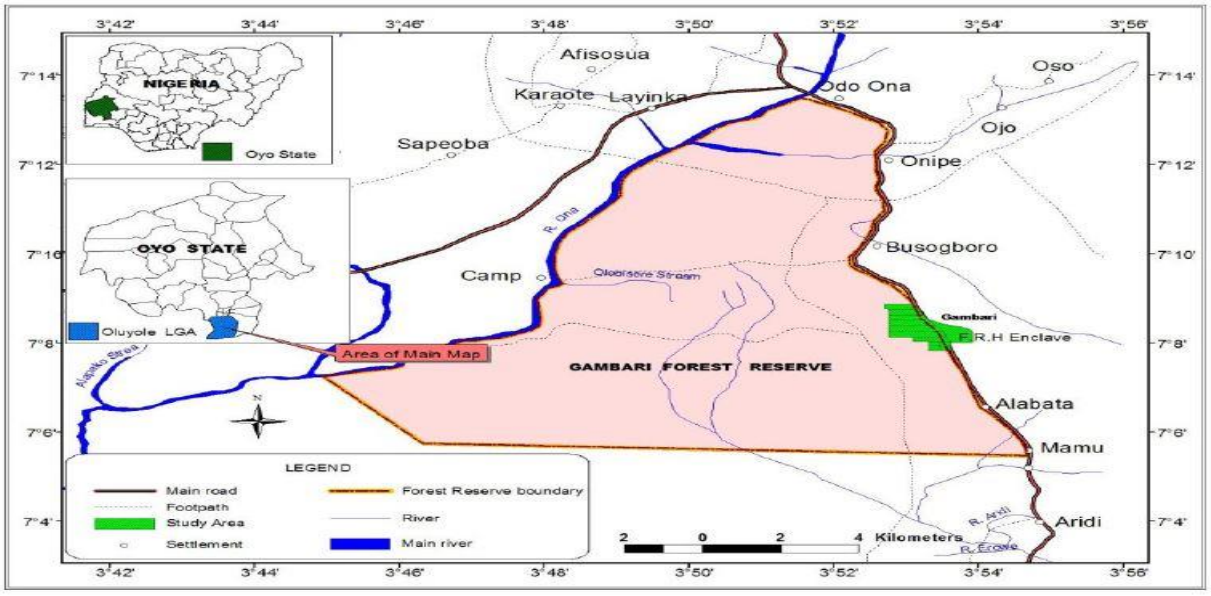


Figure 1: Map of the Study Area

Data Collection

In order to assess the impact of agroforestry practices on plant diversity, three sites were purposively selected. These include two *Taungya* sites (*Taungya* used to establish Teak as the major forest tree species (TAT) and *Taungya* with Obeche as the main forest tree species (TAO) and a natural forest (NF) with which the plant diversity in the agroforestry plots was compared. The *Taungya* sites, which are each approximately two hectares (2ha) in size, were part of forest reserve formerly but now de-reserved. In each site, three plots of dimension 25m x 25m were randomly mapped out. Within each of the plots, five quadrats of size 5mx5m were also established within which the floristic composition and structural plant species diversity were assessed. All the plant species encountered were identified and enumerated up to the species level.

Data Analysis

Data collected were analyzed by estimating the species density (ha^{-1}), diversity index and similarity index. In addition, one-way Analysis of variance (ANOVA) was used to compare the diversity index of different sites. Least's significant difference (LSD) was used to separate the mean

Species density was calculated as:

Species density (ha^{-1}) = $\frac{Number\ of\ plant\ species}{area\ of\ plot}$ x10, 000 (Udoakpan, *et al.*, 2013)

Shannon-Weiner diversity index was used to calculate the species diversity on plot basis:

Shannon-Weiner diversity (H^1) = $-\sum pi \ln pi$

$$pi = \frac{Ni}{N}$$

Where, Ni = total number of individuals of species I.

N = total number of individuals of all species

Similarity index was calculated using:

$$Sorensen's\ similarityindex(SI) = \frac{a}{a+b+c} \times 100$$

Where, a = number of species present in both sites

b = number of species present in site 1 but not in site 2

c = number of species present in site 2 but not in site 1

RESULTS

Species density and richness in the sites

Taungya with Teak as dominant species (TAT) had a total of 1,0266 individual plants per hectare (ha^{-1}), consisting of 29 plant species where *Chromolaena odorata* had the highest density (2978 ha^{-1}) while *Carpolobia lutea*, *Cola heterophyla* and *Elaeis guineensis* had the lowest density of 44 ha^{-1} per species. In the *Taungya* site with Obeche (TAO), 1,2768 individual plants comprising of 39 plant species were identified. *Trema orientalis* had the highest density (3156 ha^{-1}), whereas *Alternanthera* sp., *Baphia nitida, Diospyros dendo, Elaeis guineensis, Ficus exasperata, Nesogordonia papaverifera, Newbouldia laevis, Picralima nitida, Pterygota macrocarpa* and *Sterculia rhinopetala* had the least density of 44 ha^{-1} per species Natural forest (NF) had a total of 20302 individual plants ha^{-1} comprising of 53 plant species with *D. dendo* having the highest density (1244 ha^{-1}) while plants such as *Anchomanes diformis, Blighia sapida, Caesalpinia bonduc, Canthium* sp., *Ceiba pentadra, Celtis zenkeri, Chromolaena odorata, Cissus quadrangularis, L. cupanioides, Myrianthus aboreous, N. papaverifera, Picralima nitida, Piptadeniastrum africanum, P. marcrocarpa* and *Rauvolfia vomitoria* had the lowest density of about 44 ha^{-1} per species (Table 1).

Table 1: Species density (ha^{-1}) in the study sites

S/N	Plant Species	Common/Local name	Family	TAT	TAO	NF
1	*Aedesia baumannii*	Opeko	Compositae	.	89	89
2	*Albizia ferruginea*	False thorn albizia	Leguminosae	.	.	444
3	*Albizia zygia*	Atanza	Leguminosae	178	311	800
4	*Alchornea cordifolia*	Christmas bush	Euphorbiaceae	267	133	.
5	*Alternanthera* sp.	Prickly amaranthus	Amaranthaceae	89	44	.
6	*Anchomanes difformis*	Anchomanes	Araceae	.	.	44
7	*Anthocleista djalonensis*	Cabbage tree	Loganiaceae	.	.	800
8	*Baphia nitida*	Camwood	Papilionaceae	133	44	667
9	*Blighia sapida*	Akee apple	Sapindaceae	.	.	44
10	*Caesalpinia bonduc*	Bonduc nut	Leguminosae	89	92	44
11	*Calamus longipinna*	Rattan	Arecaceae	.	.	933
12	*Canthium glabliflorum*	Ajelora	Rubiaceae	.	.	44
13	*Carpolobia lutea*	Cattlestick	Polygalaceae	44	56	178
14	*Cedrela odorata*	Cedar	Meliaceae	.	.	400
15	*Ceiba pentandra*	Kapok	Bombacaceae	.	.	44
16	*Celtis zenkeri*	African celtis	Ulmaceae	.	.	44
17	*Centrosema pubescens*	Fodder pea	Leguminosae	667	800	.
18	*Chromolaena odorata*	Siam weed	Compositae	2978	1111	44
19	*Cissus quadrangularis*	Stemmed vine	Vitaceae	311	89	44
20	*Cola gigantea*	Oporoporo	Sterculiaceae	.	.	222
21	*Cola heterophyla*	Kola	Sterculiaceae	44	133	133
22	*Cola millenii*	Monkey kola	Sterculiaceae	.	.	89

23	*Combretum racemosum*	Bush willow	Combretaceae	1111	889	133
24	*Cordia millenii*	African cordia	Boraginaceae	133	89	.
25	*Culcasia scandens*	Agunmona	Araceae	.	89	267
26	*Daniellia ogea*	Daniella	Leguminosae	.	.	89
27	*Diallium guineense*	Tumble tree	Leguminosae	.	.	89
28	*Diospyros dendo*	Date plum	Ebenaceae	.	.	1244
29	*Diospyrous mespiliformis*	Ebony tree	Ebenaceae	89	44	67
30	*Elaeis guineensis*	Palm tree	Palmae	44	44	79
31	*Ficus exasperata*	Sand paper tree	Moraceae	89	44	729
32	*Funtumia elastica*	Male funtum	Apocynaceae	.	.	400
33	*Gliricidia sepium*	Gliricidia	Leguminosae	267	90	.
34	*Harungana madagascariensis*	Dragon's blood tree	Hypericaceae	.	.	533
35	*Holarrhena floribunda*	False rubber tree	Apocynaceae	.	.	889
36	*Icacina tricantha*	Icacina	Icacinaceae	311	89	844
37	*Lecaniodiscus cupanioides*	Lecaniodiscus	Sapindaceae	.	178	44
38	*Leptoderis* sp.	Leptoderris	Leguminosae	178	.	444
39	*Leptoderis brachyptera*	Leptoderris	Leguminosae	.	89	222
40	*Massularia acuminata*	Ijebu chewing stick	Rubiaceae	.	.	899
41	*Microdesmis puberula*	Microdesmis	Euphorbiaceae	222	489	1111
42	*Morus mesozygia*	Black mulberry	Moraceae	.	.	89
43	*Mucuna pruriens*	Mucuna	Leguminosae	.	.	178
44	*Musanga cecropioides*	Corkwood	Moraceae	.	756	756
45	*Myriantus arboreus*	Myriantus	Moraceae	.	.	44
46	*Nesogordonia papaverifera*	Danta	Sterculiaceae	.	44	44
47	*Newbouldia laevis*	Tree of life	Bignoniaceae	222	44	.
48	*Olax subscorpioidea*	Stink ant forest	Olacaceae	.	844	844
49	*Parquetina nigrescens*	African parquetina	Periplocaceae	133	44	.
50	*Paullinia pinnata*	Hippo cola	Sapindaceae	400	489	.
51	*Phyllanthus discoideus*	Peacock berry	Euphorbiaceae	267	.	580
52	*Phyllanthus mullerianus*	Myrobalan	Euphorbiaceae	.	133	.
53	*Picralima nitida*	Picralima	Apocynaceae	.	44	44
54	*Piper guineense*	Climbing black pepper	Piperaceae	.	.	89
55	*Piptadeniastrum africanum*	Dahoma	Leguminosae	.	.	44
56	*Pterocarpus osun*	Bloodwood	Leguminosae	.	667	667
57	*Pterygota macrocarpa*	African pterygota	Sterculiaceae	.	44	44
58	*Pycnanthus angolensis*	Wild nutmeg	Myristicaceae	.	.	222
59	*Rauvolfia vomitoria*	Serpent wood	Apocynaceae	178	178	44
60	*Secamone afzelii*	Secamore	Asclepiadaceae	444	267	1156
61	*Sida acuta*	Hornbean-leaf sida	Malvaceae	222	178	.
62	*Spathodea campanulata*	African tulip	Bignoniaceae	.	.	89
63	*Sphenocentrum jollyanum*	Sphenocentrum	Menispermaceae	756	667	89
64	*Sterculia rhinopetala*	Brown sterculia	Sterculiaceae	178	44	933
65	*Tetracera* sp.	Cup of water	Dilleniaceae	222	133	356
66	*Trema orientalis*	Charcoal tree	Ulmaceae	.	3156	.
67	*Uapaca togoensis*	Uapaca	Euphorbiaceae	.	.	667
68	*Xylopia aethiopica*	Ethiopian pepper	Annonaceae	.	.	133
	Total			**10266**	**12768**	**20302**

TAT: *Taungya* with Teak, TAO: *Taungya* with Obeche, NF: Natural forest

Comparing the three sites, there were considerable variations in plant species density and richness. For instance, the most abundant plant species in the TAT was *Chromolaena odorata.* In the TAO, it was *Trema orientalis* while in the NF, *Diospyros dendo* happened to be the most abundant species. In terms of the population of plants' family, NF had the highest number (31)

compared to the TAT (23) and TAO (26). The most abundant family in TAT and TAO was Compositae and Ulmaceae respectively, while in the NF, it was Leguminosae.

Considering the composition of plants, NF had the highest number (1,556ha^{-1}) of tree species, which accounted for about 66% of plant life forms in the site. This was followed by TAO 889 ha^{-1} (51.3%) while TAT had the lowest number (489 ha^{-1}) representing just 37.9% of plant life forms. For the shrub composition, the three sites had equal number of 267ha^{-1}. This translated to 20.7% of plant life forms in TAT, 15.4% in TAO and 11.3% in NF. Similarly, TAT and TAO had the largest but the same number of herb of 133 ha^{-1} representing 10.3% and 7.7% of the growth habits in TAT and TAO respectively. On the other hand, NF had the lowest number (89ha^{-1}) of herb, which represents 3.8% of the growth habits. In addition, the largest number of climber was seen in TAO (444 ha^{-1}) and NF sites (444 ha^{-1}), which accounted for 18.8% and 25.6% of the growth habits in the latter and former respectively (Table 2).

Table 2: Plant species population, families and growth proportion in the three sites

Plant variables	Teak	Obeche	Natural forest
Most abundant species	*Chromolaena odorata*	*Trema orientalis*	*Diospyros dendo*
Total number of species	29	39	53
Total number of family	23	26	31
Most abundant family	Compositae	Ulmaceae	Leguminosae
Growth proportion			
Tree	489 (37.9 %)	889 (51.3%)	1556 (66.0%)
Shrub	267 (20.7%)	267 (15.4%)	267 (11.3%)
Herb	133 (10.3%)	133 (7.7%)	89 (3.8%)
Climber	400 (31.0%)	444 (25.6%)	444 (18.8%)

The highest similarity (71.8 %) was found between TAT and TAO. This is followed by TAO and NF (47.2%) while the least is the similarity between NF and TAT sites-28.3% (Table 3). In terms of the species diversity index (Table 4), NF had the highest value (3.49). This is closely followed by TAO (2.87), and the lowest was found in TAT (2.10). Result (Table 4) shows that species diversity in TAT is significantly different ($p<0.05$) from TAO as well as diversity in the NF. Conversely, difference between species diversity in TAO and NF is not significant ($p>0.05$).

Table 3: Similarity index of floristic and structural plant composition among the sites

Sites	TAT	TAO	NF
TAT	_	_	_
TAO	71.8	_	_
NF	28.3	47.2	_

Table 4: Shannon diversity index of plants composition in the three sites

Sites	Diversity Index	p-value
TAT	2.10±0.067^{a}	0.000*
TAO	2.87±0.170^{b}	
NF	3.49±0.015^{b}	

*=significant at p=0.05
Means with the same superscripts are not significantly different ($p<0.05$)

DISCUSSION

The denser population of *C. odorata* observed in TAT compared to other study sites agrees with Ohtsuka (1999), who observed that *C. odorata* competes aggressively with other plants that grow around it in open areas. Its stems however, root whenever they come in contact with the ground. According to Sahid and Sugau (1993), its allelopathic effect is more pronounced on the growth of herbs, grasses and shrubs than that of trees. The presence of important tree species like *C. milleni, B. nitida, D. dendo, F. exasperata, N. papaverifera, N. laevis, P. nitida* and *S. rhinopetala* within the *Taungya* plots support the findings of Akinbisoye *et al.* (2014) that agroforestry land use would contribute to the conservation of indigenous woody tree species. Although, TAT site

was dominated by *C. odorata,* an herbaceous plant but *T. orientalis* and *D. dendo,* which are trees in terms of their growth habit, were the most abundant plant species in TAO and NF, respectively.

Generally, based on the overall variation observed in plant composition, NF had the highest density of plant species, families, as well as the number of trees on hectare basis. TAO site equally had a better plant composition compared to that of TAT site. All these facts put together therefore imply that agroforestry with *T. scleroxylon* as the major tree species encourages biodiversity more than the agroforestry with *T. grandis*. The finding confirms the assertion by Brent and Jean-Marc (2005**),** that, the overall contribution of agroforestry to biodiversity conservation depends on the land use and the major tree species under consideration. The higher diversity index observed in the natural forest compared with the two *Taungya* sites may be ascribed to the incessant clearing and other management practices embarked upon in the agroforestry land for the cultivation and survival of the agricultural crops. This continuous clearing may have impeded the regeneration of some species that were not found in the two sites. This however is one of the most important weaknesses of agroforestry in species conservation as reported by Darkoh (2003) and corroborated by Moreno-Calles *et al.* (2009) that, threatened species are vulnerable to being lost when land is cleared for the establishment of crop fields.

Despite the various management practices however utilized in the two *Taungya* sites, result from this study indicated that the plant diversity estimated from the natural forest was not significantly different from the site with Obeche as dominant species but significantly higher than the diversity in site with Teak as dominant species. According to Sarrailh and Ayrault (2001) as also reported by Onefeli and Adesoye (2014), *T. grandis* can inhibit the growth of indigenous tree species when they are grown together. This insignificant difference between the plant diversity in the natural forest and obeche agroforestry site therefore put Obeche at a higher advantage in species conservation than the Teak. This finding is further supported by the comparatively high similarity index obtained between the natural forest and the Obeche Taungya site. In this regard, similarity index may also be considered as one of the yardsticks for measuring the conservation potential of an agroforestry system.

CONCLUSION

This study revealed that Taungya practice of plantation establishment has the potential for biodiversity conservation on the long run. Although, the capability of natural forest ecosystem to sustain plant species diversity is higher than that of *Taungya* system but the difference is negligible. However, in a situation where there are numerous threatened species that cannot be easily regenerated, the potential may be weakened and not be able to meet the target. Therefore, if *Taungya* system is to be considered for tree species diversity conservation, local farmers who are the major stakeholder should be encouraged with incentives such as provision of loans to maintain their agricultural crops (Moreno-Calles *et al.,* 2009). Such strategy will in one way or the other motivate them to spare and foster any tree species or other plant growth habit identified to be conserved by the land owner. Obviously from the findings, *Taungya* system with *T. scleroxylon* stand at a better chance for species richness and diversity conservation than *Taungya* with *T. grandis*, nevertheless, the latter would be the best option if herbaceous plant is to be conserved.

REFERENCES

Adekunle, V. A. J, Akindele, S.O and Fuwape, J.A. (2002). Impacts of over exploitation on biodiversity, yield and sustainable use of tropical rainforest ecosystem: A case study of Omo Forest Reserve, Southern Nigeria. In: Abu, J.E., Oni, P.I. and Popoola, L. (Eds.) Forestry and challenges of sustainable Livelihood. *Proceedings of the 28th Annual Conference of the Forestry Association of Nigeria.* Pp. 252-163.

Akinbisoye, O.S., Oke, S.O., Adebola, S.I., and Mokwenye, A.I. (2014). Influence of *Taungya* Agroforestry system on Diversity of Native wood species and soil physico- chemical properties in Nigeria. *International Journal of scientific and research*, 4(3): 1-15.

Brent, S. and Jean-Marc, B. (2005). The potential for agroforestry to contribute to the conservation and enhancement of landscape biodiversity. *World agroforestry centre (*ICRAF), Kampala, Uganda.

Darkoh M.B.K. (2003). Regional perspectives on agriculture and biodiversity in the drylands of Africa. *J. Arid Environ,* 54(1):261-279.

Etigale, E.B. (2010). Trees species diversity, abundance and regeneration potential in Ukpom River Forest Reserve, Cross River State, Nigeria. Unpublished *M.Sc. Dissertation, University of Uyo, Uyo, Nigeria,* pp 49-84.

King, K.F.S. (1968). *Agri-silviculture: The Taungya System.* Bulletin No. 1, Department of Forestry, Universityof Ibadan, Nigeria.

King, K.F.S. (1979). Agroforestry and the utilization of fragile ecosystems. *Forest Ecology and Management* 2: 161-168.

Moreno-Calles, A., Casas, A., Blancas, J., Torres, I., Masera, O., Caballero, J., Garcia-Barrios, L., Perez-Negron, E., and Rangel-Landa, S. (2009). Agroforestry systems and biodiversity conservation in arid zones: the case of the Tehuacan Valley, Central Mexico. *Agroforest Systems* p17.

Nair, P. K. R. (1993). *An Introduction to Agroforestry*. Kluwer Academic Publishers, London. 489P.

Ohtsuka, T. (1999). Early stages of secondary succession on abandoned cropland in north-east Borneo Island. *Ecological Research* 14(3): 281-290.

Olajide, O. Udo, E.S. and Out, D.O. (2008). Diversity and population of timber tree species producing valuable non-timber products in two tropical rainforests in Cross River State, Nigeria. *Journal of Agriculture and Social Science* 4(2): 65-68.

Onefeli, A.O. and Adesoye, P.O. (2014). Early Growth Assessment of Selected Exotic and Indigenous Tree Species in Nigeria.

South-east European forestry 5 (1): 45-51.
Roche, L. (1993). Shifting cultivation and soil conservation in Africa: the practice of agri-silviculture in the tropics with special reference to Nigeria. Ecology Report Series No 5, UNESCO, Darkar, Pp 30-47.
Sahid, I.B and J.B. Sugau (1993). Allelopathic effects of lantana (*Lantana camara)* and Siam weed (*C. odorata)* on selected crops. *Weed Science* 41(2):303-308
Sarrailh, J.M. and Ayrault, N. (2001). Rehabilitation of Nickel Mining sites in New Caledonia. *Uasylva*, 207 (52):16-20.
Udoakpan, U.I., Nelson, I.U. and Jacob, D.E. (2013). Ecological survey of Plant species producing valuable Forest Products in two Sacred Forest in South Eastern Nigeria. *ARPN Journal of Science and Technology*, 3(4): 415- 420.
Udofia, S.I., Jacob, D.E., Owoh, P.W. and Samuel, N.S. (2011). Stemming environmental degradation: The afforestation approach. *Nigerian Journal of Agriculture, Food and Environment* 7(1): 22-27.

Influence of Agroforestry Trees Leafy Biomass and Nitrogen Fertilizer on Crop Growth Rate (CGR) and Relative Growth Rate (RGR) of Maize

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ABSTRACT

The use of legume tree pruning as mulch in agroforestry system is a common practice to maintain soil organic matter and improve soil fertility in the tropics. The study was conducted to determine the influence of agroforestry trees leafy biomass and nitrogen fertilizer on crop growth rate and relative growth rate of maize. The experiments were laid out as 3 x 4 x 2 factorial in a split-split plot design with three replicates. The factors considered were: control, biomass species (Albizia lebbeck and Parkia biglobosa) as main plots, four rates of nitrogen (0, 40, 80, 120 kg N ha^{-1}) as sub-plots, and two maize varieties (DMR-ESR-7 and 2009 EVAT) as sub-sub plots. Data were analysed using descriptive and inferential statistics (ANOVA) at $\alpha = 0.05$. Incorporation of leafy biomass was significant in 2015 on RGR, while nitrogen application was significant on CGR. 2009 EVAT had higher CGR in 2015 at 4-6 and 6-8 WAP. Incorporation of Albizia leaves enhanced the growth of maize than Parkia leaves. Farmers are therefore, encouraged to use Albizia leaves as mulch to enrich their soil for maize production and most especially, in case of in availability of inorganic fertilizers. Though, production of maize with biomass and application of 120 kg N ha^{-1} will bring better growth of maize.

Keywords: Agroforestry trees, fertilizer, growth, incorporation, leafy biomass

INTRODUCTION

The agricultural production system in Nigeria as well as other developing countries of the world has deteriorated due to decline in soil fertility which has resulted to lack of capacity to produce enough food for their teeming population (Oyebamiji *et al.,* 2014). Farming systems in Nigeria and all over the tropics are under threat due to declining soil fertility (Adjei-Nsiah, 2012). It is increasingly evident that declining soil fertility is the most widespread, dominant limitation on yields of maize (*Zea mays* L.) and the sustainability of maize-based cropping systems in Africa (Ajayi *et al.,* 2007). Lack of soil fertility restoring resources, soil erosion and unequal soil fertility management have been reported to contribute to soil fertility depletion in arid Africa (Bationo *et al.,* 2007; Vanlauwe and Giller, 2006). Leguminous trees that are nitrogen fixing trees are known to play complementary or alternative role as source of organic fertilizer and have the potential to sustain soil fertility (Adjei-Nsiah *et al.,* 2004).

In many tropical agricultural systems with limited access to fertilizers, tree biomass is often used to meet the N requirements of annual crops (Olujobi, 2012). A major challenge in this approach is to ensure that N in the applied biomass is efficiently utilized by crops. Synchronizing release of N from decomposing biomass with demand (uptake) by crop (Swift, 1987) will lead to increased N-use efficiency of the incorporated biomass (Becker *et al.,* 1994a), and will in turn minimize the opportunity for N loss (Myers *et al.,* 1994).

In terms of biomass transfer, Ladd *et al*., (1981) reported that leaves from N-fixing agroforestry trees were made to accumulate in the soil in form of soil organic matter from the litter fall, or biomass transfer which eventually is made available to companion crops after mineralization. Kamara *et al*. (1994) and Xu *et al*. (1993) established that the N supply by the biomass transfer from the legumes was not sufficient to achieve optimum companion crop yield in semi-arid tropics. In agroforestry systems, plant residues in form of tree leaf litter or biomass transfer enter the soil system which serves as sources of nutrients and organic matter when they decompose and could contribute to the maintenance of soil fertility. Residue decomposition rates and nutrient release or mineralisation patterns are controlled by both biotic and abiotic factors, the most important of which is residue quality (Mungai and Motavalli, 2006; Teklay *et al.,* 2007). Inorganic fertilizers have gained popularity because, they are easy to manage, handle and apply. This is because it is easier to synchronize the release of nutrients and plant uptake with inorganic fertilizers than with manure (McLaughlin *et al.,* 2002). Chemical or mineral fertilizers have been reported to increase cereal rooting depth and root proliferation (Belford *et al.,* 1987). However, few smallholder farmers can afford mineral fertilizers, and those using fertilizer hardly use the recommended rates (Mugwe *et al*., 2009). Moreover, the little fertilizer available when added to the soil is often utilised with poor efficiency (Vanlauwe *et al*., 2010a) due to environmental or soil-related factors (e.g. P fixation by sesquioxides, leaching and volatilization of N etc.) as well as management factors (e.g. poor timing or placement of fertilizer). Soil fertility research in recent years has shifted its attention towards the combined application of organic and inorganic nutrient sources to

reverse the negative nutrient balances in cropping system in agriculture in sub-saharan Africa (Vanlauwe *et al.,* 2001). Organic and inorganic materials have complimentary roles, and their judicious and balance use would allow high and sustained yields (Bationo and Makwunye, 1991). Integrated use of inorganic and organic fertilizers is essential to attain sustainable agricultural development (Abera *et al.*, 2005). Technologies that combine mineral fertilizers with organic resources are best because they increase fertilizer use efficiency, reduce risks of acidification and provide a more balanced supply of nutrients (Donovan and Casey, 1998).

MATERIALS AND METHODS

Experimental Field Design

The experiments were laid in split-split plot design in 3 x 4 x 2 factorials with three replicates. The plot dimensions were 4m x 3m. Leafy biomass of *Albizia lebbeck* and *Parkia biglobosa* were pruned and incorporated fresh into the soil at the rate of 6 kg for each of the *Albizia* and *Parkia* biomass plots (B_1 and B_2), respectively and plots without incorporation of leafy biomass (B_0). The leafy biomass was incorporated into the soil for two cropping seasons (2014 and 2015). Four levels of N fertilizers were split applied as: N_0, 0 kg N ha^{-1} (control); N_1, 40 kg N ha^{-1}; N_2, 80 kg N ha^{-1}; N_3, 120 kg N ha^{-1} and half were applied at 2 weeks after planting (WAP). The remaining amount was applied 5 (WAP). The two varieties of maize used were (DMR- ESR- 7 (Yellow Maize) and 2009 EVAT (White Maize) were obtained from Katsina State Agricultural and Rural Development Authority (KTARDA). Two maize varieties were planted (two maize seeds were planted per hole, at equal depth and it was later thinned to one) by conventional spacing of 75 cm x 25 cm two weeks after incorporation of leafy biomass of *Albizia* and *Parkia* into the soil. Thinning was also done 2 (WAP).

Plant Tissue Analysis of Agroforestry Tree Species

Samples of harvested leaves were air dried at room temperature and ground to be analysed for initial contents of N, C, lignin and polyphenols. Total N was analysed by Macro-Kjeldahl digestion, followed by distillation and titration (Anderson and Ingram, 1993; Brandstreet, 1665). Lignin was determined by the Acid Detergent Fibre (ADF) method as outlined in (Anderson and Ingram, 1993). The polyphenol was extracted in hot (80^0C) 50% aqueous methanol and determined calorimetrically with tannic acid as a standard measurement (Anderson and Ingram, 1993; Hagerman, 1988).

Data Collection

Five maize plants were randomly selected within each of the net plots 4 m x 1.5 m (6 m^2) with a tag for periodic observations at 4, 6, 8 and 10 WAP during the crop growth cycle for pre- harvest data collection. At harvest, these same five tagged plants were still used to obtain yield.

Crop growth rate (CGR)

This is a measure of the rate of dry matter production per unit time or dry matter increment per unit area of land per unit time. It was calculated using the formula described by Watson (1952) and Radford (1967).

$$\text{Mean CGR} = \frac{W_2 - W_1}{T_2 - T_1} \times \frac{1}{GA}$$

Where, W_2 and W_1were dry weight in grammes (g) per plant at times T_1 and T_2 in weeks respectively. GA is the ground area. The unit of measurement is g $m^{-2}wk^{-1}$.

Relative growth rate (RGR)

This is the increase in plant material per unit of initial plant material per unit of time as described by Blackman (1919), Briggs *et al.,*(1920) and Radford (1967). It was computed as follows:

$$RGR = \frac{\log_e W_2 - \log_e W_1}{T_2 - T_1}$$

Where, W_1 and W_2 were plant dry weights in grammes (g) per plant at times T_2 and T_1 respectively. The unit of measurement is g $^{-1}wk^{-1}$.

Data Analysis

Data were analysed by subjecting to using Analysis of Variance (ANOVA) at 5 % level of significance to determine differences in the treatment effect. The Duncan's New Multiple Range Test (Duncan, 1955) was used to separate means of differences among the treatments.

RESULTS

Chemical composition of *Albizia lebbeck* and *Parkia biglobosa* leafy biomass

The plant materials showed variations in their chemical compositions during 2014 and 2015 cropping seasons. The leaves of *Albizia* contained more N (leading to lower C: N ratio) than *Parkia. Albizia* had the highest concentration of lignin with mean value of 11.06, while *Parkia* had highest concentration of C: N ratios with mean value of 6.30. The result in (Table 1) showed that *Parkia* had low N and C contents.

Crop Growth Rate (CGR)

Incorporation of between was not significant on crop growth rate in 2014, but significant at 4-6 and 8-10 WAP in 2015 where *Albizia* had high significant value at 4-6 WAP a *Parkia* in 8-10 WAP than *Albizia*. In 2014, the control treatment produced significantly lower values of crop growth rate than in plots supplied with other nitrogen. Among the nitrogen treated plots; the values were mostly comparable, but numerically increased with 120 kg N ha^{-1} at 8-10 WAP. No significant difference among varieties in 2014 was observed. In 2015 at 4-6 and 6-8 WAP, 2009 EVAT had significant higher values than DMR-ESR-7 (Table 2).

Relative growth rate (RGR)

There was no significant difference in plots amended with both *Albizia* and *Parkia* biomass in 2014, but significant at 4-6, 6-8, and 8-10 WAP in 2015, where *Albizia* produced significant higher RGR at 6-8 WAP. In 2014, at 4-6 WAP among the nitrogen treated plots the values were mostly comparable, but significant increase at 40 kg N ha^{-1} rate. Maize varieties had no significant effect seasons

Table 1. Chemical composition of the leafy biomass of *Albizia lebbeck* and *Parkia biglobosa*

Component	N %	C %	Lignin %	Polyphenol %	C: N
Albizia lebbeck					
2014	3.32a	18.62a	11.37a	0.65b	5.60b
2015	3.16a	18.65a	10.74a	0.48b	5.90b
Means	3.24a	18.64a	11.06a	0.57b	5.75b
Parkia biglobosa					
2014	2.85b	17.81b	8.35b	0.87a	6.20a
2015	2.44b	15.52b	8.13b	0.63a	6.40a
Means	2.65b	16.67b	8.24b	0.75a	6.30a

Table 2: Influence of biomass and nitrogen rate on crop growth rate (g/m^2/wk) of two maize varieties in 2014

	Crop growth rate (g/m^2/wk)					
	2014			2015		
Treatment	4-6 WAP	6-8 WAP	8-10 WAP	4-6 WAP	6-8 WAP	8-10 WAP
Biomass (B)						
Control	0.011a	0.008a	0.010a	0.016b	0.007a	0.011a
Albizia	0.016a	0.010a	0.010a	0.023a	0.008a	0.005b
Parkia	0.013a	0.006a	0.013a	0.011c	0.007a	0.008ab
SE±	0.00179	0.00156	0.00245	0.00158	0.00152	0.00187
Nitrogen (N) Kg ha-^{1}						
0	0.009b	0.004b	0.006c	0.016b	0.007a	0.004b
40	0.016a	0.009a	0.007bc	0.014b	0.006a	0.009ab
80	0.012ab	0.011a	0.014ab	0.013b	0.006a	0.012a
120	0.016a	0.008ab	0.017a	0.023a	0.010a	0.007ab
SE±	0.0019	0.0017	0.0026	0.00200	0.00171	0.00218
Variety (V)						
DMR- ESR- 7	0.013a	0.008a	0.010a	0.014b	0.005b	0.006a
2009 EVAT	0.013a	0.008a	0.012a	0.019a	0.009a	0.010a
SE±	0.0015	0.0079	0.0020	0.00144	0.00119	0.00166
Interaction						
B x N	S*	S*	S*	S*	NS	S*
B x V	NS	NS	NS	S*	NS	NS
V x N	NS	S*	S*	S*	S*	S*

WAP: Weeks after planting. S* Significant at 5% level of probability. NS: Not significant.

abc; Means followed by the same letter(s) within the same column and treatment are not significantly different at 5% level of probability using DMRT.

Table 3: Influence of biomass and nitrogen rate on relative growth rate (g/m^2/wk) of two maize varieties in 2014 and 2015

	Relative growth rate (g/m^2/wk)						
	2014			2015			
Treatment	4-6 WAP	6-8 WAP	8-10 WAP	4-6 WAP	6-8 WAP	8-10 WAP	
Biomass (B)							
Control	0.286a	0.106a	0.080a	0.484b	0.078ab	0.090a	
Albizia	0.279a	0.086a	0.060a	0.563a	0.058b	0.038b	
Parkia	0.268a	0.078a	0.075a	0.418c	0.098a	0.080ab	
SE±	0.020	0.0163	0.013	0.024	0.012	0.013	
Nitrogen (N) Kg ha^{-1}							
0	0.240b	0.070a	0.066a	0.481b	0.079a	0.056ab	
40	0.322a	0.084a	0.052a	0.460b	0.074a	0.079ab	
80	0.268ab	0.119a	0.082a	0.453b	0.077a	0.099a	
120	0.281ab	0.088a	0.087a	0.559a	0.079a	0.042b	
SE±	0.023	0.018	0.014	0.030	0.014	0.016	
Variety (V)							
DMR- ESR- 7	0.275a	0.092a	0.067a	0.481a	0.071a	0.060a	
2009 EVAT	0.281a	0.089a	0.076a	0.496a	0.084a	0.078a	
SE±	0.017	0.013	0.010	0.022	0.010	0.012	
Interaction							
B x N	NS	NS	NS	S*	NS	S*	
B x V	NS	NS	NS	S*	S*	S*	
V x N	NS	NS	NS	S*	NS	NS	

WAP: Weeks after planting. S* Significant at 5% level of probability. NS: Not significant.

ab; Means followed by the same letter(s) within the same column and treatment are not significantly different at 5% level of probability using DMRT.

DISCUSSION

Incorporation of *Albizia* biomass in plots that received them was discovered to perform better due to its better quality materials which contained higher average N content of N (3.24 %) and C (18.64 %) and lower average C: N (5.75) (Table 2) than *Parkia* materials. Giller and Wilson, (1991), also reported that plant residues with a smaller C: N (< 30:1) is liable to decompose more rapidly with a net mineralization of N after incorporation into the soil. Hence, N is rapidly released and made readily available for crops.

The non-significant influence of biomass on relative growth rate (RGR) could be that soil conditions produced by *Albizia* and *Parkia* biomass incorporation exerted the same effect on relative growth rate (RGR). There was no significant difference in 2014 on RGR, while there was significant difference in 2015 on RGR because the condition of the soil had been improved better than the way it was in 2014.

Vegetative growth and development of maize was stimulated by the application of nitrogen which enhanced the increase as observed crop growth rate (CGR) and relative growth rate (RGR). Increase in these growth components revealed the essentiality of nitrogen as a protein constituent and important component of many other compounds needed for plant growth processes (Onasanya *et al.*, 2009). Nitrogen application was significant on CGR and RGR while their non-significance could be as a result of leaf fall due to the leaf ageing. 2009 EVAT had higher CGR in 2015 except at 8-10 WAP that had no significant response. There was no significant response to maize varieties on RGR.

CONCLUSION

Incorporation of *Albizia* into the soil improved the soil quality for better growth. Leafy biomass and application of 120 kg N ha^{-1} is agronomically suitable for both 2009 EVAT and DMR-ESR-7 maize production.

REFERENCES

Abera, T. Feyissa, D., Yusuf, H. and Georgis, T. G. (2005). Influence of precursor crops on inorganic and organic fertilizers Response of maize at Bako, Western Oromiya, *Ethopia. Pakistan Journal of Biological Science*. 8(12): 1678-1684.

Adjei-Nsiah, S. (2012). Role of Pigeon pea cultivation in soil fertility and farming system sustainability in Ghana. *International Journal of Agronomy*, pp 1- 8.

Adjei-Nsiah, S., Leeuwis, C. and Giller, K. E. (2004). "Land tenure and differential soil fertility management practices among native and migrant farmers in Wenchi, Ghana: implications for interdisciplinary action research," NJAS-Wageningen *Journal of Life Sciences*, vol. 52, no. 3-4, pp. 331-348.

Ajayi, O. C., Akinnifesi, F. K., Sileshi, G. and Chakeredza, S. (2007). Adoption of renewable soil fertility replenishment technologies in the southern African region: Lessons learnt and the way forward. *Natural Resources Forum*,*31*(4), 306-317.

Anderson, J. M, Ingram, J. S. (1993). Tropical soil Biology and Fertility, A Handbook of Methods. CAB International, Wallingford. pp 45-49.

Bationo, A. and Mokwunye, A. V. (1991). Role of manures and crop residue in alleviaoduction: with special reference to the Sahelian Zones of West Africa. Fertilizer Research. 29:117-125.

Becker, M., Ladha, K. J. and Ottow, J. C. G. (1994a). Nitrogen losses and lowland rice yield as affected by residue nitrogen release. *Soil Science Society of America Journal* 58: 1660-1665.

Blackman, V. B. (1919). The compound interest and plant growth. *Annals of Botany* 33: 352-360.

Brandstreet, R. D. (1965). Kjeldahl method for organic N. Academic Press. London. 85 pp.

Briggs, G. E., Kidd, F. and West, C. (1920). Quantitative analysis of plant growth, part I and II. *Annals of Applied Biology*. 7: 103-123 and 202-223.

Donovan, G. and Casey, F. (1998). Soil Fertility Management in Sub-Saharan Africa. World Bank technical Paper No. 408. The World Bank, Washington DC, Pp.60.

Duncan, D. B. (1955). Multiple Range and Multiple F- test. *Biometrics.* 11:1-42.

Giller, K. E. and Wilson, K. J. (1991). *Nitrogen fixation in Tropical Cropping Systems*. CAB International, Wallingford, U. K.

Hagerman, A. (1988). Extraction of tannin from fresh and preserved leaves. *Journal of Chemical Ecology.* 2(2): 95- 121.

Kamara, C. S, Chikasa, P. and Mateke, S. M. (1994). SADC/ICRAF Agroforestry Research Project. Annual Report No 80.Chalimbana, Lusaka, Zambia. pp 64-75.

Ladd, J. N., Oades, J. M. and Amalo, M. (1981). Distribution and recovery of N from legume residues decomposing in soils sawn to wheat in the field. *Soil Biology and Biochemistry* 13: 251-256.

McLaughlin, N. B., Gregrorich, E. G., Dwyer, L. M. and Ma, B. L. (2002). Effect of organic and inorganic amendments on

mouldboard plow draft. *Soil Tillage Res.* 64, 211-219.Mugwe, J., Mugendi, D., Mucheru-Muna, M., Merckx, R., Chianu, J. and Vanlauwe, B. (2009). Determinants of the decision to adopt integrated soil fertility management practices by smallholder farmers in the Central highlands of Kenya. *Experimental Agriculture* 45: 61-75.

Mungai, N. W. and Motavalli, P. P. (2006). Litter quality effects on soil carbon and nitrogen dynamics in emperate alley cropping systems. *Applied Soil Ecology.* 31, 32-42.

Myers, R. J. K., Palm, C. A., Cuevas, E., Gunatilleke, J. U. N. and Brossard, M. (1994). The sysnchronization of nutrient mineralization and plant nutrient demand. In: Woomer, P. L and swift, M. J (ed.) The biological management of tropical soil fertility. Tropical Soil Biology and Fertility Programme (TSBF), Nairobi, Kenya. p 81-116.

Olujobi, O. J. (2012). Effect of application regime of *Gliricidia sepium* leaf litter on the growth and yield of maize (*Zea mays L.*). *Journal of Agriculture and Veterinary Sciences*.4**:** 34-39.

Onasanya, R. O., Aiyelari, O. P., Onasanya, A., Oikeh, S., Nwilene, F. E., and Oyelakin, O. O. (2009). Growth and yield response of maize *(Zea mays L.)* to different rates of nitrogen and phosphorus fertilizers in southern Nigeria. *World Journal of Agricultural Sciences* 5(4): 400-407.

Oyebamiji, N. A., Adedire, M. O. and Aduradola, A. M. (2014). Evaluation of participation in agroforestry practices among farmers' in Odeda Local Government Area of Ogun State, Nigeria. 37th Annual Conference of Forestry Association of Nigeria (FAN). Pp 210-217.

Radford, P. J. (1967). Growth analysis formulae. Their use and abuse. Crop Science 7(3): 171-175.

SAS Institute (2000). Statistical Analysis Systems, Users Guild, Cary, N.C USA. 949.Pp.

Swift, M. J. (1987). Tropical Soil Biology and Fertility: Interregional Research Planning Workshop. Special Issue 13, Biology International. Paris France: IUBS(ed).system for the tropics. *Natural Resources Forum, 24*, 137-151.

Teklay, T., Nordgren, A., Nyberg, G. and Malmer, A. (2007). Carbon mineralization of leaves from four Ethiopian agroforestry species under laboratory and field conditions. *Applied Soil Ecology.* 35, 193-202.

Valauwe, B., Wendt, J. and Diels, J. (2001). Combined application of organic matter fertilizer. In: Tian, G., Ishida, F. and Keatinge, J. D. H. (eds), Sustaining Soil Fertility in West Africa, SSSA Special publication no. 58, *Soil Science Society of America*, Madison, Wisconsin, U.S.A., Pp. 247-279.

Vanlauwe, B. and Giller, K. E. (2006). Popular myths around soil fertility management in Sub- Saharan Africa. *Agriculture, Ecosystems and Environment* 116:34-46.

Vanlauwe, B., Bationo, A., Chianu, J., Giller, K. E., Merckx, R., Mokwunye, U., Ohiokpehai, O., Pypers, P., Tabo, R., Shepherd, K. D., Smaling, E. M. A.,Woomer, P. L. and Sanginga, N. (2010a). Integrated soil fertility management. Operational definition and consequences for implementation and dissemination. *Outlook on Agriculture* 39:17-24.

Watson, D. J. (1952). The physiological basis of variation in yield. *Advances in Agronomy* 4:101-145.

Xu, Z. H., Myers, R. J. K., Saffigna, P. G. and Clapman, A. L. (1993). Nitrogen cycling in Leucaena (*Leucaena leucocephala*) alley cropping in semi-arid tropics. Response of maize growth to additions of N fertiliser and plant residues. *Plant and Soil* 158: 73-82.

Relevance of Agroforestry Practices in Sustainable Watershed Management

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ABSTRACT

This paper reviewed relevance of Agroforestry practices in sustainable watershed management in order to provide information on benefits that could be derived from watershed areas. Sustainable watershed management entails implementation of programmes to achieve watershed functions for the present and future generation. Benefits attached to watershed cannot be overemphasized but there is need to address results of anthropogenic activities around watershed area. Therefore, management of watershed requires an integrated multi-sectoral approach for excellent deliver. Due to role of agroforestry in conservation of natural resources, adoption of agroforestry practices along watershed area should be encouraged.

Keywords: Agroforestry, watershed, management, degradation

INTRODUCTION

Watershed can be defined as an area of land from which surface water and subsurface water drains downhill into the river, lake, wetland, sea or ocean (World Bank, 2000). It is also an area of land that drains down slope until a common point is reached housing diversity of vegetation along the course of the flow as a form of protection to the soil and other factor aiding continuous flow (World Bank, 2000). Watershed is an ecosystem with complex interacting natural components biotic and abiotic. Anthropogenic activities have a lot of direct influence on the quality and quantity of surface water, groundwater and other natural resources in the watershed. River flow and water quality down stream are influenced by upstream. Surface and groundwater systems have a limited tolerance for stresses; this can lead to long term problems which are costly and difficult to remediate (Sarvade, 2015). The main components of watershed management are resource conservation, crop production and alternate land-use systems (Sarvade, 2015). Watershed management must be integrated and address both water and the related land resources that affect or are affected by water (Sarvade, 2015).

Integrated watershed management approaches are now considered as innovative options for sustaining watershed ecosystems while improving human welfare (Sarvade, 2015).. This encompasses the holistic approach to managing watershed resources that integrates forestry, agriculture, pasture and water management, which can be broadened to rural development with a strong link to the livelihoods of the local people (Moffatt *et al*., 2004).

Watershed mainly comprised of surface and groundwater, wetlands, forests, soil, fisheries, flora and fauna and the sustainable relationship among these resources lies on watershed management. Meanwhile, the management is not so much about managing natural resources, but about managing human activity as it affects these resources (Sarvade, 2015). Towards prevention of poor water quality, shortage of water, flooding and erosion, there should be a concerted effort among governments, municipalities, industries, and landowners.

Concept of Sustainable Watershed Management

Projects, plans and programmes that are implemented to achieve watershed functions for the present and future generation as they affect the plants, animals, and human communities within a watershed boundary is refer to as sustainable watershed management. It involves management of land, water, energy and greenery integrating allthe relevant approaches appropriate to socioeconomic background for a pragmatic developmentof a watershed. The main components of watershed management are resource conservation,

crop production and alternate land-use systems (Sarvade, 2015). Therefore, in order to avert watershed degradation and ensure its sustainability the following practices must be ensured:

- Utilization of watershed land area based on its capability;
- Protection of its fertile top soil and vegetative cover throughout the year;
- Minimization of siltation of tanks, reservoirs and lower fertile lands;
- Water harvesting for supplemental irrigation and in-situ conservation of rain water;
- Diversion of gullies and construction of check dams for increasing ground water Recharge;
- Increasing cropping intensity through inter and sequence cropping ;and
- Improving infrastructural facilities for storage, transport and agricultural marketing,

Factors Affecting Sustainable Management of Watershed

Watershed degradation is the major factor that affects sustainable of watershed management. It is the loss of value of watershed over time, including the productive potential of land and water, accompanied by marked changes in the hydrological behaviour of a river system resulting in inferior quality, quantity and timing of water flow (FAO, 1998). The degradation is as a result of destruction of natural vegetation which is primarily caused by deforestation (Plate 1). Other major causes are wildfire and overexploitation. Deforestation not only occurs as a result of firewood extraction and other Non-Timber Forest Products (NTFPs) by the local population but also as a result of the creation of arable as well as pastoral land. As population increases, pressure on exploitation of forest resources increases and results in loss of forest cover. The menace eventually leads to increase in upstream erosion and downstream sedimentation. Because of these, many watersheds are losing their capacity to regulate runoff (Asinwa *et al*., 2016).

Causes of Watershed Degradation

Unsustainable activities are adversely affecting the environment. There is increasing evidence that the climate system is experiencing pronounced change with an increase of $0.6^{o}C$ in the mean surface temperature of the planet since the end of nineteenth century (IPCC, 2001). Similarly, land use changes are changing watershed landscape patterns, ecosystem functions and climate dynamics; they affect bio-diversity and hydrology and the transport of latent heat, carbon dioxide, nutrients and pollutants. Humans constitute one of the main driving forces behind environmental change (Enwelu, *et al*., 2010) through overexploitation, overgrazing, unadjusted irrigation techniques, socioeconomic and political motivated changes

Overexploitation

Overexploitation occurs when arable land is used beyond its fertility potential without substituting the loss of nutrients by fertilizers or appropriate fallow periods (Grainger, 1990). Contributing to the overexploitation are population increase, mechanized farming and cultivation for cash crops. These activities can lead to a variety of erosion features such as Gully erosion, landslides and alternation of discharge and should thus be prevented in order to provide sustainable watershed.

Overgrazing

This occurs when the number of livestock on a unit of land is too large. Resultant effect of this is the destruction of natural vegetation as well as soil compaction and erosion. Furthermore the photosynthesis and hence biomass production and carrying capacity is decreased. Vegetation damages occur not only due to browsing by livestock, but also due compaction. Also the lack of grazing plan such as rotation of grazing ground and national land use plan may contribute to overgrazing (Mensching, 1990). Like overexploitation, overgrazing can result in various degradation features such as alternation of discharge, change of soil moisture and gully erosion and thus might compromise the sustainable management of watershed.

Unadjusted Irrigation Techniques

The inappropriate implementation of irrigation techniques can lead to degradation, when the technical knowhow and/or the appropriate instruments are missing.
Degradation, primarily in form of salinization, occurs in this case due to a bias between water inflow and outflow or the use of salty water (Mensching, 1990).

Socio-economic and Political Causes

Various socio-economic as well as political causes can lead to land degradation. Population growth is a major root of degradation, since it contributes to overgrazing, overexploitation and deforestation. Furthermore degradation occurs due to underdevelopment, since resources are often exploited to benefit developed countries and thus little profit is left in developing countries to manage or

restore degraded areas (Mensching, 1990). Also rural-urban migration contributes to the occurrence of degradation, since urban populations need more firewood than rural populations. Hence the growth of urban populations in general, goes hand in hand with an increase in deforestation and thus degradation.

Natural Causes

Climatic factors such as the nature of rainfall (amount, intensity, variability and distribution), soil (texture, structure, depth, moisture and infiltration rate) and topography play an important role in the scope and scale of occurring degradation features. Under natural condition, soil erosion due to these causes is a natural process. However their negative effects can be amplified through human action such as farming activities within the watershed (Lal, 1990).

Agroforestry Practices and its Value in Watershed Management

Agroforestry is the combination of agricultural and forestry technologies to create integrated, diverse and productive land use systems (Garrett *et al.,* 2000). Agroforestry has the ability to provide short-term economic benefits while the farmer waits for traditional longer-term forestry products. An example of an agroforestry system is a riparian buffer planting that can attenuate flooding effects and protects water quality, while providing wildlife habitat, recreational opportunities and harvestable products, like edible berries and medicinal herbs. Agroforestry encompasses a very large and diverse set of practices ranging from croplands in which a minimal tree component has been added to complex forest production that has been integrated into an existing forest structure. Differences exist in how agroforestry is defined and perceived between tropical and temperate zones and reflect the wide variation in the climate, soils, pressures on the land and socioeconomic values where agroforestry can be applied. After examining many definitions and examples of agroforestry used globally, Nair (1985) concluded that the "strict scientific definition should stress two characteristics common to all forms of agroforestry:

• The deliberate growing of woody perennials on the same unit of land as agricultural crops and/or animals, either in some form of spatial mixture or in sequence.

• There must be a significant interaction (positive and/or negative) between the woody and non-woody components of the system, either ecologically and/or economically."

• Scientific evidence is now available to show that the spatial and temporal heterogeneity created by the agroforestry plantings can help enhance resource, increase production, reduce risk of monocultural agricultural and forestry practices, and achieve system stability and sustainability of watershed (Sanchez 1995; Ong and Huxley 1996; Lefroy *et al.,* 1999; Nair and Latt 1998; Nair 2001).

A general classification developed by Nair (1985) puts the many agroforestry practices existing worldwide into three major types based on the combination of the components (Nair 1985):

Agrisilvicultural

This involves integration of arable crops with woody plants in the same watershed management unit. The practice enhances conservation of soil fertility, protection of water and control of erosion by trees compare with having agricultural crops in the watershed

Silvopastoral

It is agroforestry practices which entails combination of pasture and/or animals and woody plants on the same land management unit. Provision of trees in the practice stabilizes the watershed better than having pasture alone on the land.

Agrosilvopastoral

This practice involves cultivation of arable crops integrated with pasture and/or animals and woody plants. Spatial or temporal arrangement of these components contribute to the sustainable of watershed in the sense that one component cushion the negative influence of the other in the watershed.

Advantages of Agroforestry in Watershed Management

Protection of Water Quality

Most watersheds contain a mixture of land uses, including forestry and agriculture. Protecting water quality requires an integrated multi-sectoral approach (Range management, Water resources management, Forestry and Agricultural) to watershed management. Streams that course through agricultural lands are often devoid of vegetation in their riparian zones and runoff containing excess fertilizers, pesticides, animal wastes, and soil sediments enters surface waters unabated. Agroforestry technologies, like riparian forest

buffers, have been shown to be effective in reducing water pollution from agricultural activities when they are well designed and properly located in a watershed (Dosskey, 2002). This is evident in River Ona at Eleyele catchment in Ibadan and Olokemeji along River Ogun in South Western Nigeria. These buffers can stabilize stream channels, slow and reduce the transport of runoff to streams. This allows more time for infiltration of water and contaminants into the soil and increases the ability of the environment to degrade pesticides and animal waste products (Dosskey, 2002). Agroforestry practices are also being adapted to design best management practices to detain and treat storm water runoff from communities and restore ecological functions to watersheds.

Conservation

Enormous loss of valuable, fertile topsoil is taking place with sediment and water. It has been estimated that average soil is displaced at the rate of about 16 t/ ha/ year and washed in to the reservoir, which is much higher than the permissible limit (Sarvage, 2015). Some of the barren portion and wasteland of the watershed can be provided with a cover through agroforestry interventions in the watershed management programme. Most especially agrisilviculture practices

Soil improvement

Agroforestry practices enrich soil by nitrogen fixation and addition of organic matter. In this way, it helps in meeting nutrient requirements of plants growing in association with trees and at the same time, the soil structure and infiltration rates are also improved.

Moderation of microclimate

The micro-climate in the neighbourhood of trees is moderated by adopting agroforestry systems and the field crops growing in association with trees get the benefit in various ways. Its pronounced effect is observed in semi-arid and arid regions where arable crops such as millet, sorghum and cowpea produce bountiful yield under shelterbelt management of tree species like *Eucalyptus spp*, *Vitellaria paradoxa* and *Parkia biglobosa*.

Agro-based cottage industries

An agroforestry practices in watershed management helps in promotion of agro-based cottage industries, such as paper pulp (Iwopin Paper Mill), herbal drugs, fibre, poultry (Zartech Nigeria Limited), piggery, dairy, bee-keeping, sericulture cultivation and so on. This will provide gainful employment and raise the standard of living of small and marginal farmers.

CONCLUSION

It is concluded that the success of agroforestry practices in sustainable watershed is dependent of well-planned and good management. It is also function of components of agroforestry provided human induced challenges were eliminated. Agroforestry systems play a great role in conservation of natural resources and adoption of agroforestry practices along watershed area should be encouraged towards achieving a sustainable watershed. Therefore, for the sustainability of watersheds in Nigeria such as Lake Chad, kanji Lake, River Niger, River Benue, River Osun, River Ona, River Ogun and so on, agroforestry practices should be encouraged.

REFERENCES

Asinwa, I. O., Kazeem-Ibrahim, F., Fapojuwomi, O. A and Oluwadara, O.P (2016):Sustainable Watershed Management for Rural Livelihoods in Nigeria. *Proceedings of the 38th Annual Conference of the Forestry Association of Nigeria held in Port Harcourt, River State. Nigeria. 7th-11th March, 2016. Pp 396-400.*

Dosskey, M.G.(2002): Setting priorities for research on pollution reduction functions of agricultural buffers. *Environmental Management* 30:641-650.

Food and Agriculture Organization.(1998): Developing participatory and integrated watershed management. Community Forestry Case Study Series No. 13. Rome. United Nations. 1992. Agenda 21, Chapter 13 "Managing Fragile Ecosystems–Sustainable Mountain Development". Rio de Janeiro, Brazil, Earth Summit (UNCED).

Garrett, H.E., Rietveld, W. J. and Fisher, R.F. (2000): North American Agroforestry: An Integrated Science and Practice.America Society of Agronomy, Inc. Madison, WI. https://www.researchgate.net/publication/284023409_Role_of_Agroforestry_in_Watershed_Management. (accessed August 20, 2016).

Grainger, A (1990): The Threatening Desert: Controlling Desertification. London: Earths can Publications Ltd. Pp. 98

Lal, R. (1990): Soil Erosion in the Tropics: Principles and Management. New York: McGraw-Hill Publishing Company Pp 76.

Lefroy, E. C., Hobbs, R. J., O'Connor, M. H., and Pate, J. S.(Eds). 1999. Agriculture as a Mimic of Natural Ecosystems. Kluwer Academic Publishers, Dordrecht, The Netherlands. 438pp.

Moffatt, S., McLachlan, S., and Kenkel, N. (2004): Impacts of land use on riparian forest along an urban - rural gradient in southern Manitoba. *Plant Ecology*, 174: 119-135.

Nair, P. K. R. (2001): Agroforestry. In: Our Fragile World: Challenges and Opportunities for Sustainable Development, Forerunner to The Encyclopedia of Life Support Systems, Chapter 1.25, Vol. I. UNESCO, Paris, France, and EOLSS, UK.pp. 375-393.

Nair, P. K. R. and. Latt, C.R (Eds). (1998): Directions in Tropical Agroforestry Research. Kluwer Acad. Publishers, Dordrecht, The Netherlands, 245 p.

Nair, P.K.R. (1985): Classification of agroforestry systems. *Agroforestry Systems* 3:97-128. Ong, C. K. and Huxley, P. A. (Eds.) (1996): Tree-Crop Interactions. CABI, Oxon, UK., 385 p.

Sanchez, P.A. (1995): Science in agroforestry. *Agroforestry Systems* 30:5-55.

Sarvade, S. S (2015): Role of Agroforestry in Watershed Management. https://www.researchgate.net/publication/284023409_Role_of_Agroforestry_in_Watershed_Management. (accessed August 20, 2016).

Shanwal, A. V. and Dhiya, S.S. (2002): Strategies for soil conservation and watershed management in shiwaliks, India. 12th ISCO Conference. Beijing. 6p

World Bank (2000): Watershed management: A review of the World Bank portfolio (1990–2000). Washington, DC, World Bank, Rural Development Department

SUB-THEME 2



Environment, Climate Change, REDD^{+} and Bio-Energy

Physico-Chemical Properties of Bio-Oil Produecd from Pyrolysis of *Gmelina arborea* (Roxb)

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ABSTRACT

A pyrolysis study on a species of Gmelina arborea was carried out in a pilot-scale reactor to investigate the effect of temperature on product distribution, i.e. bio-oil and bio char yields. The result revealed that the highest mean volume of bio-oil yield (63.12±0.409 %) was at 750^{o}C while the least mean yield of (43.20±0.603 %) was observed at 900^{o}C. The results obtained in this study indicated that optimum bio oil yield was obtained between 600-750 ºC. The high yield of bio-oil at high temperatures was due to primary reactions, such as decomposition of cellulose and hemicellulose which resulted in the bio-oil production. The mean bio-char residue recovery after pyrolytic process ranged from (54.24±2.533 to 39.35±2.921 %) the highest bio-char residue recovery was at 600^{o}C while the least bio char mean was observed at 900 ºC. This implies that bio char yield decreases as pyrolytic temperature increases. At temperatures above 750 ^{o}C, chemical reactions involving mainly the decomposition of lignin and secondary reactions involving the breakdown of the bio-oils resulted in high yields of bio-char. Characterization of the bio-oils obtained gave a pH ranging 3.13 and 3.95 for temperature of 850 and 650^{o}C. The low pH values of the bio-oils make them highly acidic, and thus corrosive. The least and highest MC of bio-oil varied between 13.00% and 25.00% at 900 ^{o}C and 600 ^{o}C respectively. The density of bio-oil varied between 1.03 and 1.15 g/cm^{3}. The calorific values of bio-oil ranged from 2.16 to 3.16 Mj/kg, for temperature between 600-700^{o}C which represent the temperature where highest mean values was observed. The ash content in the bio-oil varied from 0.17 to 2.30% for temperature between 600-700 ºC. Knowledge of the amount of ash-forming material present in a product can provide information as to whether or not the product is suitable as a fuel. The calorific values of bio char briquette ranged from 28.48 to 32.82 Mj/kg. As it is known, the high carbon content of char makes it suitable to act as fuel and chemical feedstock. The production process (pyrolysis) has eliminated all the volatile and extraneous components of the feedstock prior briquette production.The bio-oil obtained showed comparable fuel properties and can be treated as moderate grade commercial fuels. In order to utilize it as commercial transportation fuel certain enhancement in properties like density and corrosiveness have to be normalize. The thermal degradation process (pyrolysis) may help to reduce environmental pollution, deforestation at the same time providing greater amounts of desirable, renewable fuel and chemical source.

Keywords: Bio oil, Bio char, pyrolysis, *Gmelina arborea*, sawdust, calorific value

INTRODUCTION

Wood and other forms of biomass have served as major fuels for thousands of years since mankind first began to use fire for heating and cooking. Recently, interest in biomass utilization has increased owing to growing concern over the depletion of fossil fuels and global warming caused by greenhouse gas production from fossil fuel combustion. Biomass fuels, by contrast, are CO2 neutral as they are derived from fixing atmospheric CO2 by green plants photosynthesis, so their use does not add to the levels of atmospheric Carbon (E.C.). Growing interest in renewable energy technologies has led to the development of hydroelectric, solar, wave, geothermal, and wind power plants that can potentially displace fossil fuel based energy production (Demirbas, 2006). However, existing infrastructures require hydrocarbons for manufacturing goods ranging from plastics and chemicals to fuel oil, lubricating oil, and hydraulic fluids. This has led many to look towards biomass as the only sustainable alternative to fossil fuels capable of yielding petroleum like products (Huber et al., 2006, Bridgewater, 2000). As is the case with all potentially disruptive technologies, though, proper environmental mitigation and lifecycle planning must be included when considering the production and use of biofuels (Trimble, *et al*., 1984).

Pyrolysis is touted to be one of the most promising thermochemical technologies with the potential to convert cheap, local, and abundant lignocellulosic biomass such as grasses and trees into a useful form (Mohan, *et al*. 2006, Lu, *et al*.2010), and commercial scale plants, such as Kior in Mississippi, have begun construction and operations. Thermal technologies include direct combustion, gasification, liquefaction, and pyrolysis, all of which have the benefit of using lignocellulosic materials. Only pyrolysis and liquefaction produce a liquid product, and although recent work on liquefaction has shown promising results (Soria, *et al.* 2008a, Soria, *et al.* 2008b), it is currently a nascent technology with high capital costs due to the high pressures required. Pyrolysis has the advantage of low capital investment and a liquid final product that can be transported and converted via catalysis to fuels and valuable products such as food flavorings, fertilizers, resins, and other specialty chemicals that are fully compatible with existing petroleum infrastructure.

MATERIALS AND METHODS

Feedstock

Gmelina arborea sawdust collected from Ijebu Ode, Ogun State, Nigeria was used after oven dried. The sawdust is in abundance because of the present state of its utilization as timber for construction and other applications.

Sample Collection

Approximately 1000 grams of sawdust samples of *Gmelina arborea*, was used at each temperature regimes (600 ^{o}C, 650^{o}C, 700 ^{o}C, 750 ^{o}C) and oven-dried at 103±2^{o}C for 24 hours to 12% moisture content. Six replicates of bio-oil were produced at each temperature regime.

Bio Oil Production

Pyrolytic chamber was fabricated (Plate 1) for the conversion of *Gmelinaarborea* sawdust to bio-oil. The metallic container (pyrolytic chamber) was filled with 1000 grams of the samples and placed inside the reactor which was connected to a condenser. The evolving gas was distilled in the condenser to form Bio oil as shown in (plate 2) which was collected inside a conical flask.

Products Analysis of Bio oil

Yield of each pyrolysis product was estimated using the following formula:

$$Liquid\ \text{Yield}\ (\%) = \frac{\text{wt. of liquid produced}}{\text{wt. of initial pyrolysis material}} \text{x}\,100$$

$$Solid\ \text{Yield}\ (\%) = \frac{\text{wt. of solid produced}}{\text{wt. of initial pyrolysis material}} \text{x}\,100$$

(Source: Fuwape and Faruwa, 2011)

Characterization of Bio Oil

Characterizations of the bio oil were based on the following parameters; the proximate analysis and calorific value. The proximate analysis was performed to determine the volatile matter, ash content of the bio oil which was determined according to ASTM-E 872 and ASTM-D 482 respectively. The fixed carbon contents were calculated by difference between the percentage ash content and the percentage volatile matter. The moisture content of the bio oil was determined using Karl Fischer Titrator, type 784 KFP Titrino, Metrohm based on ASTM D 1744. The bio-oil was titrated with standard Karl Fischer reagent to an electrometric end point. The density was determined according to (ASTM D 4052)using digital density analyzer. The calorific value of Gmelina arborea bio oil was determined using oxygen-bomb calorimeter, Leco AC-350 under controlled conditions based on ASTM D-240..The pH of the bio-oil was measured using a pH meter from Eutech Instruments. The viscosity was measured with a Cannon–Fenske up–flow viscometer and the flow was observed at 40^{o}C. The acid value was determined by using Potentiometric Titrimeter, 702 SM Titrino, Metrohm automatic recording and the determination was done by titrimetry based on ASTM D 664. The pour point and cloud point was determined according to ASTM D97 and (ASTM D2500) respectively. The flash point of the bio oil is a measure of the volatility of the oil, as well as its ease of ignition and it was determined according to ASTM D93.

RESULTS AND DISCUSSION

Physical Properties of Bio-Oil from *Gmelina arborea*

Table 1 shows the Bio oil yield from *Gmelina arborea* at seven different temperature regimes (600 ^{o}C, 650^{o}C, 700 ^{o}C, 750 ^{o}C, 800 ^{o}C, 850 ^{o}C and 900 ^{o}C). The physical properties which includes bio-oil yield (%), Density (g/cm^3), pH, % Moisture content, Pour point, Cloud point, Flash point, Kinematic viscosity and Acidic value including the elemental analysis. The temperature employed for pyrolysis is one of the major parameters, which affect the distribution of products and bio-oil characteristics. The kinetic mechanism for pyrolysis shows that primary reactions occur between 200 and 470^{o}C, which results in the formation of bio-char. Above 400 ^{o}C, the bio-char slowly undergoes various physical and chemical changes to produce bio-oil and non-condensable gas (NCG) (Garcia-Perez, 2010; Mullen *et al*., 2010).Generally, maximum yields of bio-oils were obtained between 700^{o}C and 750^{o}C. As the temperature increased, bio-oil yield increased and reached a maximum of 63.12%wt. at 750 ^{o}C. It then decreased considerably at 800^{o}C. Non-condensable gas (NCG) yields also increased as the temperature increased from 600 to 750^{o}C. The high yield of bio-oil at high temperatures was due to primary reactions, such as decomposition of cellulose and hemicellulose which resulted in the bio-oil production as illustrated in figure 1.



Plate 1**: Pyrolytic Reactor**



Plate 2: **Bio oil Produced**

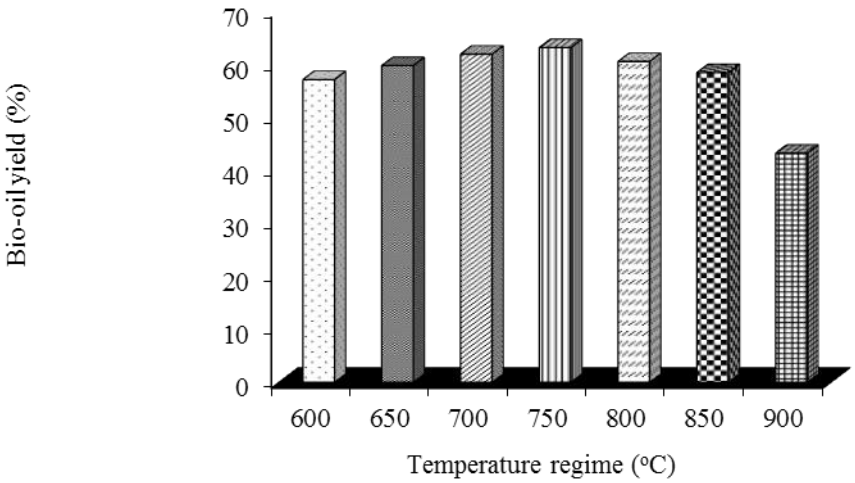


Fig 1: Graph of Mean Bio Oil yield (%)

Bio-char yields, however, decreased as the temperature increased from 600^{o}C to 900^{o}C. At temperatures above 750 ^{o}C, chemical reactions involving mainly the decomposition of lignin and secondary reactions involving the breakdown of the bio-oils resulted in

high yields of bio-char.The bio-oil appeared brownish dark with a strong acid smell. The results obtained in this study compared well with those reported on the effect of temperature on fast pyrolysis of corn cobs, straw and stover in fluidized-bed reactors by some authors including Putun*et al*. (2001), Lee *et al.* (2005), Asadullah*et al*. (2008), Zhang *et al*. (2009), Aannidou*et al*. (2009) and Mullen *et al*. (2010). As the temperature increased, secondary reactions such as cracking or breaking-up of the vapours into small unit occurred, which decreased the bio-oil yields. Mullen *et al*. (2010) reported maximum bio-oil yields from the pyrolysis of corn cobs in a fluidized-bed reactor at 550 ^{o}C to be 61.0 %wt. However, Shen and Gu (2009) also reported maximum bio-oil yields from fast pyrolysis of cellulose at 580^{o}C at a residence time of 0.4 sec. According to these authors, as the temperature increased, NCG yields also increased. However, char yields decreased due to secondary reactions which occurred.Similar results were reported for the fast pyrolysis of rice straw and husk in a fluidized-bed reactor by some authors including Putun*et al*. (2001), Lee *et al*. (2005), Worasuwannarak*et al*. (2007), Jung *et al.* (2008) and Ji-lu (2008). The result of the density presented in table 1 revealed that there is significant difference in the values obtained at different temperature regimes, with bio oil produced at 700^{o}C to 750^{o}C having the highest density value of 1.15 g/cm^{3} which was lower when compared with report of Solantausta*et al;* (1993) with approximated value of 1.2 g/cm^{3}. Density is a fundamental physical property that can use in conjunction with other properties to characterize bio-oil products. The characteristics of the oils derived from *Gmelina arborea* at the seven temperature regimes were very similar to the characteristics of other biomass pyrolytic oils. The most prominent characteristic is the nature of the oil due to high oxygen content (Biotherm, 1999).

The bio oil exhibit a low pH value which ranged from 3.67, 3.95, 3.75, 3.77, 3.52, 3.13 and 3.48 for temperatures of 600^{o}C,650^{o}C,700^{o}C,750^{o}C,800^{o}C,850^{o}C and 900^{o}C respectively and they are therefore, corrosive. The pH of the bio-oil increased with rise in pyrolysis temperature and later decreased at 800^{o}C. A similar change in pH of the bio-oil with the increase in pyrolysis temperature was also documented elsewhere (Antonakou, *et. al*, 2006). The result of the percentage moisture content is presented in table 1 which revealed that percentage moisture content of the bio oil produced from *Gmelina arborea* sawdust decreases as the pyrolysis temperature increases and bio-oils produced at 600^{o}C had highest moisture content of 25.00 %wt while bio oil obtained at 900^{o}C had the least moisture content of 13.00%wt. These values fall within those reported by Mullen *et al*. (2010) for bio-oils obtained from the fast pyrolysis of hardwoods which had moisture contents, which ranged from 15.0 to 30.0 %wt. The high MC could be due to the high MC of the biomass and some dehydration reactions, which occurred during pyrolysis.The result of the pour point revealed that the pour point of bio oil produced from *Gmelina arborea* sawdust increases at 600^{o}C-750^{o}C and later decreases at temperature 800^{o}C to 900^{o}C. The highest pour point value of 58.00 ^{o}C was recorded at temperature of 750^{o}C which will not cause any trouble in most of the tropical regions but in colder regions with sub zero climate it may have freezing problems.

Cloud point is important in that it defines the temperature at which a cloud or haze of crystals appear in the fuel under prescribed test conditions which generally relates to the temperature at which crystals begin to precipitate from the fuel in use. The result of the cloud point revealed the highest cloud point value of 61.83 at temperature of 750 ^{o}C while the lowest cloud point of 45.00 was observed at 900^{o}C. The cloud point of bio oil produced from *Gmelina arborea* differs at each of the temperature regimes used. This result was in contrast to literatures on cloud point.

The result of the flash point is presented in (table 1) revealed that the flash point values of bio oil from *Gmelina arborea* increased as the temperature increases with highest flash point of 103.83 at 850^{o}C and 900^{o}C respectively while the least flash point of 72.67^{o}C was observed at 700^{0}C. The result obtained in this report is in line with (Khor, et. al., 2009, Chiaramonti et.al, (2003) on pyrolysis of oil palm empty fruit bunches in which the flash point of their report ranged between 65^{o}C to 99^{o}C. Flash point is a measure of the liquid temperature necessary for the vapors above a pool of the fuel to ignite by passing a flame through the vapors. This is also a measure of the volatility of the oil, as well as its ease of ignition. The higher this number, the safer the oil is to handle, because the risk of accidental vapor ignition is reduced.

Kinematic viscosity at 40 ^{o}C for the bio oil are: 15.00 cSt, 20.00, 17.50, 20.00, 21.00, 25.00 and 25.50 cSt each for temperature at 600^{o}C,650^{o}C,700^{o}C,750^{o}C,800^{o}C,850^{o}C and 900^{o}C respectively (Table1). Further analysis of bio-oil (produced at 750^{o}C) showed that its viscosity increased as the measurement temperature increased. The high viscosity value of bio oil from *Gmelina arborea* will inhibit free flow of the bio oil. Viscosity is a property that represents the flow characteristics of that fuel. High viscosity in a fuel, leads to several problems such as incomplete combustion, formation of deposits at the tip of injection nozzles and contamination of lubricating oils (Hassan and Sani, 2006). The values shown above suggest that, the bio-oil under study require upgrading in order to conform to recommended specification with respect to kinematic viscosity.

Acidity makes bio-oil very corrosive and extremely severe at elevated temperature, which imposes more requirements on construction materials of the vessels and the upgrading process before using bio-oil in transport fuels. The result of the acid value of bio oil produced from *Gmelina arborea* presented in table1 revealed the highest acid value of 98.18 mg,KOH g^{-1} at temperature of 750^{o}C while the least acid values of 11.22 mg,KOH g^{-1} and 12.62 mg,KOH g^{-1} was observed at temperature of 700^{o}C and 800^{o}C respectively. Hence, the corrosivity of *Gmelina arborea* bio oil is comparable to that of bio-oil from rice husk (Zheng, 2007), but is lower than that of (Ikura's*et.al,* 2003) study because there is more organic acid in the hardwood bio-oil with pH of 2.37. the result of acid value of bio

oil from *Gmelina arborea* fall within the study of (Mohamad*et. al.*, 2009) on pyrolysis of oil palm empty fruit bunches with acid value of bio oil vary between 68 and 82 mg,KOH g^{-1}

Proximate Analysis of Bio-Oil produced from *Gmelina arborea*

Proximate analysis is the quickest and simplest way of investigating the fuel quality of biomass materials. Higher value of ash content also affects heating value. High volatile matter content indicates that the material is more volatile than solid fuels whereas there is decrease in amount of fixed carbon during pyrolysis.After pyrolysis the volatile matter content of the bio oil from *Gmelina arborea* reduces between the different temperature regimes with bio oil produced at 700^{o}C has the highest mean percentage ash content of 2.30%, while bio oil produced at 600^{o}C has the least mean percentage ash content which ranged from 1.0±0.003 to 0.81±0.002, 0.54±0.02to 0.30±0.002 and 0.25±0.002to 0.17±0.002 for temperatures of 750, 650, 900, 700, 600, and 850^{o}Crespectively which indicates higher biomass to liquid fuels from this species. As a result of decrease in volatile matter content from 97.44% at temperature of 600^{o}C to 31.88% at temperature of 900^{o}C, fixed carbon of the samples increases significantly which means there is less liberation of fixed carbon and this may be due to its chemical composition and presence of high extraneous materials.

According to the proximate analysis results (table 2), percentage ash content and volatile matter were the required prerequisite for the determination of heating value of the samples. It was observed that there is significant difference in the percentage ash content and volatile matter at different temperature regimes used. Ash is an impurity that will not burn which reduces handling and burning capacity, it increases handling cost and affects combustion efficiency causes clinkering and slagging. Excessive ash in fuel can cause fouling deposits in the combustion equipment. Ash is the incombustible material, which remains when fuel is burned. Ash is detrimental in combustion processes in which it lowers the calorific value of the fuel. Excessive amounts of ashcauses high wear in pumps and injectors and lead to deposits in combustion equipment while high volatile matter content indicates easy ignition of fuel.

The result of the bio char yield presented in (table 2) revealed that the highest bio char yield of 54.24% was observed at temperature of 600^{o}C while the least yield of 39.35% was also observed at temperature of 900^{o}C. This further confirm results of previous report on bio char yield which decreases as the reaction temperature increases, thereby the results obtained in this study compared well with those reported on the effect of temperature on fast pyrolysis oil and char yield of corn cobs, straw and stover in fluidized-bed reactors by some authors including Putun*et al*. (2001), Lee *et al.* (2005), Asadullah*et al*. (2008), Zhang *et al*. (2009), Ioannidou*et al*. (2009) and Mullen *et al*. (2010). This is illustrated in figure 2.

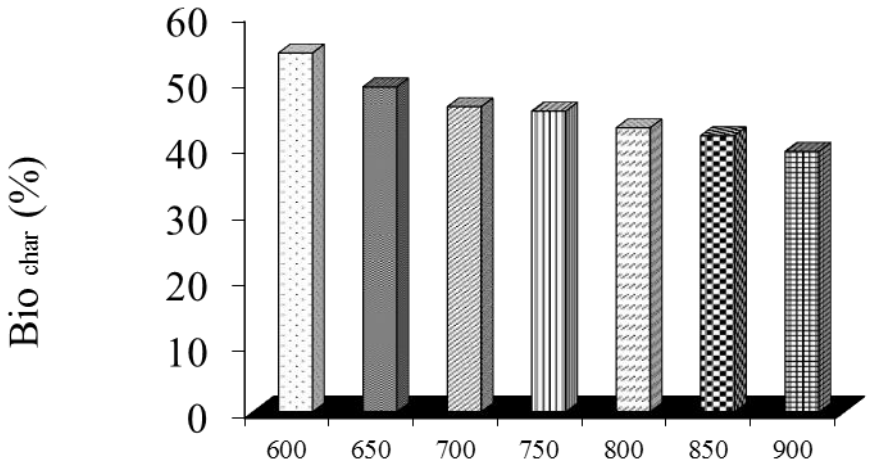


Fig 2: Graph of Mean Bio char yield (%)

The result obtained for the heating value of bio oil indicated that the heating value of bio oil start to increase at temperature of 600 to 700 and later decreasing from temperature of 750^{o}C to 900^{o}C (Table2).This implies that the optimum heating value of bio oil produced *from Gmelina arborea* sawdust is visible between the temperatures of 600^{o}C to 700^{o}C which ranged from 2.16 - 3.16 Mj/kg, which is much lower than that of gasoline, diesel fuel and petroleum (Sensor, *et.al*., 2000).

CONCLUSION AND RECOMMENDATIONS

During this study, the experiments of pyrolysis on *Gmelina arborea* biomass were performed in a fixed bed reactor. The main products obtained from the pyrolysis of *Gmelina arborea* were bio-oil, char and the yields of which depend mostly on the pyrolysis conditions. The pyrolysis conversion increases up to the final pyrolysis temperature of 900 ºC, although the bio-oil yield increase up to750 ºC, after which there is a significant decrease in the yield. As a result of thermal destruction of *Gmelina arborea* sawdust during pyrolysis, there was a significant change in the bio-oil yield across the temperature regimes. The results obtained in this work indicated that optimum bio oil yield was obtained between 600-750 ºC. The physical properties of the bio-oil obtained from *Gmelina arborea*, such as density, pH, moisture content, pour point, cloud point, flash point, acid value, and kinematic viscosity fall within the acceptable range for fuel production. The selected wood species is therefore suitable for production of bio-oil with acceptable physical and chemical properties. The thermal degradation processes (pyrolysis), may help to reduce environmental pollution, deforestation at the same time providing greater amounts of desirable, renewable fuel and chemical source.The calorific values of bio-oil ranged from 2.16 to 3.16 Mj/kg, for temperature between 600-700 ºC which is much lower than that of gasoline (47 Mj/kg), diesel fuel (43 Mj/kg) or petroleum (42 Mj/kg) (Sensoz*et al*., 2000). The ash content in the bio-oil varied from 0.17 to 2.30% for temperature between 600-700 ºC. Knowledge of the amount of ash forming material present in a product can provide information as to whether or not the product is suitable as a fuel. The pH values of the bio-oil varied between 3.13 and 3.95. Meanwhile, the acid values of bio-oil in the range of 11.22 and 98.18 mg KOH g^{-1} depending on the production condition. The density of bio-oil varied between 1.03 and 1.15 g/cm^3 . The moisture content of bio-oil varied between 13.00% and 25.00%. Water is important in many ways-increasing water usually reduces viscosity, improves stability and reduces heating value of the bio oil.

Based on the output of this work, the following recommendations are therefore suggested:

- Char residues can be used for physical or chemical absorption and as catalyst support or base material for fertilizer or land enrichment.
- Popularization of briquette technology would also provide employment; reduce deforestation and also reduce quantity of wood waste going into landfills. Also people can acquire alternative source of fuel at cheaper cost.
- Upgrading of the bio-oil produced to high grade liquid fuel for further use in internal combustion engines and other applications. In addition, the high oxygen and water contents make it incompatible with convectional fuels although it may be utilized in a similar way. Some conversion or upgrading for oxygen and water removal and stabilization is necessary to give a product that is fully compatible with conventional fuel.

REFERENCES

ASTM D664-11a, Standard Test Method for Acid Number of Petroleum Products by Potentiometric Titration.2011. ASTM International: West Conshohocken, PA.

ASTM D1744. 1988. Standard test method for water in liquid petroleum products by KalrFischer reagent. Easton, MD, American Society for Testing and Materials.

ASTM D2500. 1988. Standard test method for cloud point of petroleum oils. Easton, MD,American Society for Testing and Materials.

ASTM D 482, 2007.Standard test method for ash from petroleum products. American Societyfor Testing and Materials,USA.

ASTM D93. 1991. Standard test method for flash point by PenskyMartens closed tester. Easton MD, American Society for Testing and Materials.

ASTM D4052. 1988. Standard test method for density and relative density of liquids by digitaldensity meter. Easton, MD, American Society for Testing and Materials.

American Society for Testing Material, ASTM E 872-82, 2006, Standard test method for volatile matter in the analysis of particulate wood fuels, West Conshohocken, (Pennsylvania): ASTM International.

ASTM, 1998: D97-96: Standard test method for pour point of petroleum products. In: Annual Book of ASTM standard, vol.05.01.ASTM Philadelphia, PA, pp 76-79.

ASTM, 1998: D240-92: Standard test method for heat of combustion of liquid hydrocarbon fuels by bomb calorimeter. In: Annual Book of ASTM standard, vol.05.01.ASTM Philadelphia, PA, pp 133-140.

Antonakou, E.V., V.S. Dimitropoulos, and A.A. Lappas 2006: Production and Characterization of Bio-Oil from Catalytic Biomass Pyrolysis. Thermal Science, 10(3): p. 151 - 160.

Asadullah M., Rahman M.A., Ali M.M., Motin M.A., Sultan M.B., Alam M.R. and Rahman M.S., Jute stick pyrolysis for bio-oil production in fluidized bed reactor, Bioresource Technology 99, 2008, pp. 44-50.

ASTM, 1992: D4442. Direct Moisture content Measurement of wood and wood-base materials, Annual Book of ASTM standards.

ASTM, 1982: E 872: Volatile matter in the analysis of particulate wood fuels, Annual Book of ASTM standards

ASTM, 1995- E 1755: Ash in biomass, Annual Book of ASTM standards.

Bridgwater, A.; Peacocke, G. 2000: Fast pyrolysis processes for biomass. Renew. Sustain. Energy Rev .pp 1–73.

Chiaramonti, D., Bonini, M., Fratini, E., Tondi, G., Gartner, K., Bridgwater, A. V., Grimm, H. P., Soldaini, I., Webster, A., Baglioni,

P 2003: Development of Emulsions from Bio mass Pyrolysis Liquid and Diesel and Their Use in Engines – Part 1: Emulsion Production, Biomass &Bioenergy, 25 pp. 85-99; Part 2: Tests in Diesel Engines, Bi mass & Bioenergy, 25pp. 101-111

Demirbas, A.2006.Global renewable energy resources.Energy Sources Part A Recovery Util. Environ. Eff28, 779–792.

E.C. http://ec.europa.eu/research/energy/nn/nn_rt/nn_rt_bm/article_1111_en.htm. Elliott, D. C. 1986. Analysis and Comparison of Biomass Pyrolysis/Gasification Condesates Final Report, PNL-5943, Contract DE-AC06-76RLO.

Fuwape, J.A. and Faruwa, F. 2007: Bioenergy: Conservation and Utilization of wood biofuel in Nigeria. In: Proceeding of Division 5 IUFRO conference, October 29-Nov. 2nd 2007. Tapei Taiwan. Pp.81

Garcia-Perez, M., T. Lewis, C.E. Kruger. 2010. Methods for Producing Biochar and Advanced Biofuels in Washingotn State. Part 1.Literature Review of Pyrolysis Reactors.First Project Report.Department of Biological Systems Engineering and the Center for Sustaining Agriculture and Natural Resources, Washington State University.137 pp.

Hassan, L.G.andSani, N.A. 2006: Preliminary Studies on Biofuel Properties of Bottle Gourd (Lagenariasiceraria)Seeds Oils.Nigerian *Journal of Renewable Energy*.14,(1&2): 12-15

Huber, G.W.; Iborra, S.; Corma, A. Synthesis of transportation fuels from biomass: Chemistry, catalysts, and engineering. Chem. Rev. **2006**, 106, 4044–4098.

Ioannidou, O., A. Zabaniotou, E. V. Antonakou, K. M. Papazisi, A. A. Lappas, and C. Athanassiou. 2009. "Investigating the Potential for Energy, Fuel, Materials and Chemicals Production from Corn Residues (Cobs and Stalks) by Non-catalytic

Ikura, M., Stanciulescu, M. and Hogan, E. (2003). Emulsification of pyrolysis derived bio-oil in diesel fuel. Biomass and Bioenergy, 24(2003), 221-232.

Ji-lu Z., Wei-ming Y. and Na-na W., Bio-oil production from cotton stalk, Energy Conversion and Management 49, 2008, pp.1724–1730.

Jung, S.-H., B.-S.Kang, and J.-S. Kim, Production of Bio-Oil from Rice Straw and Bamboo Sawdust under Various Reaction Conditions in a Fast Pyrolysis Plant Equipped with a Fluidized Bed and a Char Separation System. Journal of Analytical and Applied Pyrolysis, 2008.**82**(2): p. 240 - 247

Khor KH, Lim KO, Zainal ZA, 2009: Characterization of bio-oil: a by-product from slow pyrolysis of oil palm empty fruit bunches, Am. J. of Applied Sci. 6, pp1647-1652.

Lee, K-H., Kan, B-S, Park, Y-K and Kim, J-S. 2005: Influence of reaction temperature, pretreatment, and a char removal system on the production of bio-oil from rice straw by fast pyrolysis, using a fluidized bed. Energy and Fuels; 19: 2179-2184.

Lu, Q.; Zhang, Z.-F.; Dong, C.-Q.; Zhu, X.-F.2010: Catalytic upgrading of biomass fast pyrolysis vapors with nano metal oxides: An analytical Py-GC/MS study. Energies 3, 1805–1820.

MohamadAzriSukiran, Chow Mee Chin and Nor Kartini Abu Bakar 2009: Bio-oils from Pyrolysis of Oil Palm Empty Bunches," American Journal of AppliedSciences, vol. 6, no. 5, pp. 869-875.

Mohan, D.; Pittman, C.U., Jr.; Steele, P.H. 2006: Pyrolysis of wood/biomass for bio-oil: A critical review. Energy Fuels 20, 848–889.

Mullen, C. A., Boateng, A. A., Goldberg, N. M., Lima, I. M., Laird, D. A. & Hicks D. A. (2010).Bio-oil and bio-char production from corn cobs and stover by fast pyrolysis.Biomass and Bioenergy, 34, 67-74.

Putun, A.E. ;Ozcan, A. ; Gercel, H.F. ; Putun, E. Production of biocrudes from biomass in a fixed-bed tubular reactor: product yields and compositions. 2001 Fuel. 80 1371-1378

Shen, J., Wang, X. S., Perez, M. G., Mourant, D., Rhodes, M. J., Li, C. Z. (2009). Effects of particle size on the fast pyrolysis of oil malee woody biomass. Fuel. 88, 1810-1817.

Soria, A.J.; McDonald, A.G.; Shook, S.R. 2008: Wood solubilizationand depolymerization using supercritical methanol. Part 1: Process optimization and analysis of methanol insoluble components (bio-char). Holzforschung, 62, 402-408.

Soria, A.J.; McDonald, A.G.; He, B.B. 2008: Wood solubilization and depolymerization by supercritical methanol. Part 2: Analysis of methanol soluble compounds. Holzforschung, 62, 409–416.

Solantausta, Y., Nylund N., Westerholm M., Koljonen T., Oasmaa A.1993: Wood pyrolysis oil as a fuel in a diesel power plant. Bioresource Technology, Vol. 46, pp. 177-88

Sensoz S, Angin D, Yorgun S, Kockar OM. Bio-oil . 2000: production from an oilseed crop: fixed-bed pyrolysis of rapeseed (Brassica napus L.). Energy Sources; 22:891–9.

Trimble, J.L.; Vanhook, R.I.; Folger, A.G. Biomass for energy: The environmental-issues.Biomass 1984, 6, 3–13.

Worasuwannarak, N., Sonobe, T., Tanthapanichakoon, W., 2007: Pyrolysis behaviors of rice straw, rice husk, and corncob by TG-MS technique. J. Anal. Appl. Pyrol. 78, 265-271.

Zheng, J. 2007: Bio-oil from Fast Pyrolysis of Rice Husk: Yields and Related Properties and Improvement of the Pyrolysis System. *Journal of Analytical and Applied Pyrolysis*, Vol.80, No.1, (August 2007), pp. 30-35, ISSN 0165-2370

Zhang, H., 2009: Catalytic Fast Pyrolysis of Biomass in a Fluidized Bed with Fresh and Spent Fluidized Catalytic Cracking (FCC) Catalysts.Enegry& Fuels.23: p. 6199 -6206.

Table 1: Physical properties of pyrolytic oil produced from *Gmelina arborea* sawdust

Temperature regime (^{o}C)	Bio-oil yield (%)	Density (g/cm^{3})	pH	%moisture content	Pour point (^{0}C)	Cloud point (^{0}C)	Flash point (^{0}C)	Kinematic viscosity(cst)	Acid value
600	57.08±0.611^{e}	1.05±0.000^{b}	3.67±0.008^{c}	25.00±0.000	45.00±0.000	47.50±0.837^{e}	89.50±0.837^{c}	15.00±0.000	48.23±0.000^{b}
650	59.72±0.168^{c}	1.03±0.000^{b}	3.95±0.063^{a}	23.00±0.000	55.00±0.000	49.67±0.516^{d}	80.50±0.548^{e}	20.00±0.000	16.83±0.000^{e}
700	61.87±0.065^{b}	1.15±0.000^{a}	3.75±0.023^{b}	21.00±0.000	57.00±0.000	61.50±0.837^{a}	72.67±0.516^{g}	17.50±0.000	11.22±0.000^{g}
750	63.12±0.409^{a}	1.15±0.000^{a}	3.77±0.004^{b}	19.00±0.000	58.00±0.000	61.83±0.408^{a}	74.67±0.516^{f}	20.00±0.000	98.18±0.000^{a}
800	60.49±0.146^{c}	1.13±0.000^{a}	3.52±0.004^{d}	17.00±0.000	56.00±0.000	58.00±0.000^{c}	85.67±0.516^{d}	21.00±0.000	12.62±0.000^{f}
850	58.39±0.185^{d}	1.05±0.000^{b}	3.13±0.012^{f}	15.00±0.000	54.00±0.000	60.00±0.632^{b}	100.83±0.408^{b}	25.00±0.000	43.48±0.000^{c}
900	43.20±0.603^{f}	1.06±0.000^{b}	3.48±0.008^{e}	13.00±0.000	52.00±0.000	45.00±0.000^{f}	103.83±0.408^{a}	25.50±0.000	25.25±0.000^{d}

Table 2: Proximate analysis of pyrolytic oil produced from sawdust of *Gmelina arborea*

Temperature regime (^{o}C)	%Ash content	%Volatile matter	% Fixed carbon	% Bio char	Heating value of bio oil (Mj/kg)
600	0.25±0.002^{f}	79.44±0.005^{a}	20.56±0.315^{f}	54.24±2.533^{a}	2.16 ±0.342^{e}
650	0.81±0.002^{c}	54.76±0.002^{b}	44.45±0.272^{c}	49.11±0.620^{b}	2.66 ±0.211^{c}
700	2.30±0.002^{a}	29.56±0.003^{e}	68.180±0.287^{a}	46.12±1.565^{bc}	3.16 ±0.211^{a}
750	1.0±0.003^{b}	42.06±7.502^{c}	49.25±0.334^{b}	45.45±1.656^{bc}	2.67 ±0.258^{b}
800	0.30±0.002^{e}	30.20±1.014^{d}	24.64±0.325^{e}	42.93±1.235^{cd}	2.68 ±0.167^{c}
850	0.17±0.002^{g}	30.69±1.433^{d}	10.46±0.204^{g}	41.73±0.384^{cd}	1.55 ±6.751^{f}
900	0.54±0.02^{d}	31.88±1.874^{d}	34.68±0.351^{d}	39.35±2.921^{d}	2.46 ±0.654^{d}

Tree of Wealth: History and Potentials of *Terminalia catappa*

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ABSTRACT

Terminalia catappa known as Indian almond is widely found in Nigeria and has its origin from south Asia. It gradually extended to Africa countries through research. It is widely planted in places like schools, hospitals, markets, public and private establishments, residential and recreational areas. This tree is used as a shade with the fruits often eaten as food by humans, some even collect the leaves for animal fodder. It was very sad that this rich tree is not being utilized to it fullness. The medicinal potentials of this tree are not well known and these potentials can form great economic values to any nation of the world if maximally utilized. Therefore, this paper provides relevant information's on the chemical, physical and strength properties of Terminalia catappa sourced from Southwestern area of Nigeria. This information will form a baseline guide to the end users, silviculturists and the policy makers.

Keywords: *Terminalia catappa*, environment, medicinal value, utilization, economic value

INTRODUCTION

Historically, the unique characteristics and comparative abundance of wood have made it a natural material for home, structure, furniture, tools, vehicles and other decorative objects. Today for the same reasons, wood is known for a multitude of uses. Wood is a ligno-cellulosic material and a renewable natural resource which is composed of cellulose, lignin, hemicelluloses and extraneous materials contained in a cellulose structure (Oriowo *et al*., 2015). The variations in the characteristics and volume of these components as well as the differences in cellular structure make wood heavy or light, stiff or flexible and hard or soft. Wood is a porous material which consists of matrix of fibre walls and air spaces. It is a non-uniform heterogeneous material. Its structure, chemical components and mechanical properties varies from pith to back, from the tree base to the top, from the stems to the branches and root (Rupert *et al*., 2002). Wood varies systematically within one growth ring and at the cellular level. The chemistry, the micro fibril angle and mechanical properties change significantly, from one cell wall layer to another (Artuz-Siegel *et al*., 1968).

More variability in wood characteristics exists due to environment factors such as light, water, temperature and internally controlled genetic factors (Larson,1969; Zobel and Jet, 1995). Wood is produced as a result of new tissue being formed as the tree grows in girth through the cambial cells. They cover the trunk and branches of the tree at the beneath (Titmuss, 1997). Wood is the oldest and the most widely used of all structure material and is of plant origin. However, not all plant possesses woody stems can produce timber suitable for as an industrial material. Panshin and Zeeuw, (1980) gave certain features that serve to distinguish woody plants. These features are vascularise, single persistent stem, perennial stem and secondary thickening. According to the WRI (1990), wood is the most valuable commodity in the world after petroleum and natural gas. This is because there is no competitive material that has all the attributes of wood. Some of these attributes are its availability in vast quantities and the renewability of its supply. Desch and Dinwoodie (1991) stated that wood that are of commercial values falls into two broad classes namely, the soft and hard. The trees that produce these two different classes of commercial timber are themselves quite distinct. The soft wood are the gymnosperm and are commonly referred to as conifers or cone bearing plants. Characteristically, these plants have needle shaped leaves and bear naked seeds. The hard woods on the other hand are the angiosperm also known as the dicotyledons. These characteristically, have broad leaves and the seed are enclosed in a seed case. This classification according to Titmuss (1997) has nothing whatsoever to do with the weight or hardness of the wood material concerned, but is based solely on its structure.

t has been estimated that there are currently more than 50,000 plant species worldwide. Only about 1000 different tree species are utilized globally while the other are either under-utilized, not utilized, or used inappropriately (Sutton, 1999; FAO, 2006). The present human population, estimated at approximately 6.5 billion in 2005 (Aktuell, 2007), has wood consumption needs within the range of

0.3 to 0.6 m^3/year/habitant. As a result, the annual wood and wood based products consumption have been calculated to be around 3.5 billion m^3, approximately 66% of which are hardwoods used mainly as fuel and the rest are softwoods used in industry (Youngquist and Hamilton, 1999). Many tree plants are found to be under-utilized or used inappropriately and one of these tree plants is *Terminalia catappa*. *Terminalia catappa* L plants are mostly found in many places like schools, churches, offices and residential areas, used as shade. *Terminalia catappa* L. is a native species of countries like Australia, Pakistan, India, Sri Lanka and many other south Asian countries (Gunasena, 2007). This tree species gradually extended it origin to Africa, most especially Nigeria, Ghana, Cameroon and other countries. It was also discovered that *Terminalia catappa* L. is commonly used as shade tree in most of these countries, due to its shape with long horizontal branches and large leaves (Gunasena, 2007). The seeds are also eaten by the people resides in the area where the trees are planted. The seeds are edible and tasty. It has many properties, particularly in oil which is known to be medicinal purposes. These tree plants is known to be multipurpose species as nearly all its parts can be of economic purposes (Gunasena, 2007). This tree has been wide known of medicinal properties which are not well disseminated to the people. The leaves of this tree have been used for treating dermatitis and hepatitis in Asia countries (Kinoshita *et al*., 2006). The extract from the leaves shows anti-oxidative, anti-inflammatory and Shepata protective actions (Gao *et al*., 2004). Recently, the tree is been used for treating cancer and diabetes prevention (Nagappa *et al*., 2003 and Masuda *et al*., 1999). Its fruits and roots are used for tanning leather and provide a black dye for dyeing cotton, rattan and as ink, although its use as a dye is presently limited, in the future it will have more demand than the synthetic dyes that are used today.

Terminalia L.is a pan tropical genus of at least 200 species, shrubs and trees, many of these species are important tall forest trees. Some are widely grown as shade trees or ornamentals and timber trees in both local and international timber market. These species are Idigbo and Afara (*Terminalia ivorensis* A. Chev and *Terminalia superba* Engl & Diels) Stace and Clive, 2002). The wood of *T. catappa* L.(Plate 1) is moderately heavy with a specific gravity of 0.59. It can be air dried easily and used as fuel. The density of the red brown wood is 450 – 720 kg/m^3 at 12% moisture content (Anonymous, 1995). The wood is pale brown to reddish brown and heartwood is light brick red to brownish red, attractive and hard but not very durable. It is commonly used for making furniture, veneer, millwork, and cabin work. It is also used in general construction, bridge ties, flooring and making boxes and crates (Anonymous, 1980). The foliage is used for silk production and found suitable for feeding silkworms most especially katkura or tasar silkworms (Anonymous, 1980). Wood, the major forest products, and a variety of purposes, such as building construction, composite manufacture, pulp and paper products, and a variety of finished materials including furniture, ports, pilings and distribution poles (Kumar and Gupta 2006).

Unknowingly, there are some tree plants species that are found within the residential area that are fast grown wood specie, which can also serves the same purposes with the endangered wood species. The information regarding the potentials of this wood species are still limited and insufficient to the end users. *Terminalia catappa* been a lesser used tree species falls under this group and information abound of this tree plant is on its physical and agronomical properties (Kumar and Gupta, 2006). Therefore, for more attention to be given to this wood species, information on its strength, physical and chemical properties should be known. This will be a baseline guide to the various wood users on the potentials of the *Terminalia catappa*.



Plate 1: *Terminalia catappa* tree

Origin of distribution

Terminalia catappa is reported to be indigenous to Andamans Island and its neighboring islands (Jayaweera, 1982). It is also reported that the wood species is native to Indian, Indo-China, and Thailand through the Malesian area to northern Australia and Polynesia (Corner, 1986). It is very common in India planted in villages, bungalow compounds and gardens for beautification and for its fruit. Presently, it is grown in Brazil, India, Ghana, Malaysia, Myanmar, Papua, New Guinea, Mexico, Peru, Puerto Rico, The Philippines, Singapore, Sri Lanka and Virging Islands. In Sri Lanka it is grown in the lowland areas in various parts of the island up to elevation of about 300m. Tropical almond (*Terminalia catappa* L.) is a native species of Southeast Asia. It is presently found in many countries of the tropics, including northern Australia, Pakistan, India, Sri Lanka and many other south Asian countries (Gunasena, 2007). It is commonly used as a shade tree in Sri Lanka and India due to its shape with long horizontal branches and large leaves. The seeds are edible and tasty; however it is not grown on a plantation scale in any of the countries (Gunasena, 2007). Many reports also indicate that the tree has many properties, particularly the oil, which resemble true almond oil, is used as a medicinal substitute (Gunasena, 2007). It a multipurpose species as all parts of the tree can be used for economics purposes. Its fruits and roots are used for tanning leather and provide a black dye for dyeing cotton, ratting and ask ink (Gunasena, 2007).

The tree has a wide range of medicinal properties. The leaves of this tress have been used in folk medicine for treating dermatitis and hepatitis in Asian countries (Kinoshita et al., 2006). The extract of the leaves shows ant oxidative, anti-inflammatory and hepa-protective actions (Gao et al., 2004). In recent years there has been an interest in Catappa due to its medicinal properties, especially in cancer (Masuda et al., 1999) and diabetes prevention (Nagappa et al., 2003). Both these diseases are increasing worldwide (Gunasena, 2007). It has been projected that diabetics will be the number one disabler and killer diseases the next 25 years (Gunasena, 2007). Apart from the Western medicines available for many of these diseases, herbal preparations are also used. The traditional herbal medicines are becoming popular throughout the world for many of these killer diseases. Therefore, the valuable properties of Catappa deserve more research attention than before to exploit it potential in herbal medicinal preparations. Although its use as a dye is presently limited, in the future it will have more demand than the synthetic dyes that are used today. Catappa is a delicious mostly consumed as Afara (Terminalia superba Engl & Diels) in Africa, Kumbuk (Terminalia arjuna Robx, ex DC) (Wight & AM) and Chuglam (Terminalia bialata (Robx) Steud) in America (Stace and Clive 2002).

The nomenclature of Catappa is as follows:

Kingdom:	Plantae (plants)
Sub Kingdom:	Tracheobionta (vascular plants)
Super Division:	Spermatophyta (Seed plants)
Division:	Magnoliophyta (dicotyledanae)
Class:	Magnoliopsida (dicotyledanae)
Sub class:	Rosidae
Order:	Myrtales
Family:	Combretaceae
Genus:	Terminalia L.
Species:	*Terminalia catappa* L.

Source: http://plants.usda.gov/

Synonyms

The synonyms of *Terminalia catappa* are *Terminalia molucana* Lamk (1783); Tropical almond procera Robx. (1832); *Terminalia latifolia* Blanco, non Swartz (1837) and *Terminalia Mauritiana* Blanco (1945).

Common/Vernacular names

Catappa is known by a variety of common/vernacular names that vary both within and from country, mainly because of its importance, distribution, multiple uses and popularity among people as presented in Table 1 below.

TABLE 1: **Common/Vernacular Names**

Country/Language	Common/Vernacular Names
Brunei	Telesai
Cambodian	Chambak Barang, Kepang, Pareang
English	Indian Almond, Singapore Almond, Tropical Almond
French	Bedamier
India	Desabadama, Grahadruma, Ingidi, Kshudrabadma, Kshudrabija, Tapasataruvu, Thilaphala, Vatana
Indonesian	Ketapang
Laos	Huu Kwang, Somz Moox Dong, Hou Koung
Myanmar	Badan
Malaysia	Jelawai ketapang. Ketapang (General), Lingkak (Penisula), (Sarawak) Telisai he hath
Philippines	Talisai (Filipino), Logo (Ilokano), Almendras (Spanish), Dalinsi (Bicol)
Papua New Guinea	Reddish Brown Terminalia (Pidgin)
Sinhala	Kottang, Catappa
Tamil	Amndi, Nattuvadumai, Pinga, Siruppinga, Vadumai
Thailand	Khon (Narthiwat), Dat mue (Trang), Taa- pang(phitsanulok, Satrun)
Vietnamese	B(Af)Ng, (General), B(Af) Ngnh (Os)C, (Ben Tre), Mo 2 c(UWS) Saigon
Nigeria	Fruit tree, almond

Sources: Lemmens and Wulijarni-Soetjipto (1992)

The Properties of the *Terminalia catappa*

The wood is pale brown to reddish brown and heartwood is light brick red to brownish red, attractive and hard but very durable. The chemical, physical and mechanical properties derived from the stem area of the tree plant are presented below.

TABLE 2: **The mean range values of physical, chemical and mechanical properties of *Terminalia catappa* from south western area of Nigeria**

Properties	Values obtained at 12 % moisture content top
Density (g/cm^3)	0.45 – 0.72
Specific gravity	0.59
Weight (g)	14.21 – 30.59
Cellulose (%)	45.43 – 57.96
Hemicellulose (%)	25.45 – 43.26
Lignin (%)	19.87 – 29.21
Modulus of rupture (N/mm^2)	27.00 – 86.62
Modulus of elasticity (N/mm^2)	6245.20 – 17606.00
Compression strength (N/mm^2)	20.10 – 42.05
Impact bending (mm)	
Work to maximum displacement (J/m)	0.10 – 0.56

Source: Oriowo *et al*., 2015

The properties derived from other parts of the tree

The composition of the fruit contains 75% moisture and 5 % protein (Lemmens and Wulijarmi-Soetjipto (1991). The sun dried kernel yields up to half of its weight as a tallow oil that contain several fatty acids such as palmatric (55.5%), oleic acid (23%), linoleic acid

(8%), stearic acid (6%) and myristic acid (2%). The protein and sugar contents of the dried kernels are 25% and 6% with about 16 % amino acids respectively. The leaves and fruit contains gallic acid, ellagic acid, corilagin, and brevifolin carboxylic acid. The leaves also contain a total of 122 hydrolyzable tannins such as punicalagin, punicalin, terflavins A and B, tergallagin, tercatain, chebulagic acid, geraniin, granatin B corilagin, but no caffeine. The seed of terminalia catappa contain a fixed oil with olein, palmitin and strearin. The oil has the specific gravity of 0.92, refractive index (1.47), moisture content (0.55 %), insoluble impurities (0.13 %). The oil content is heaviness and less dense than water (Gunasema 2007).

The potentials of *Terminalia catappa*

Food Uses

The fruits have delightfully flavored seeds from which bland edible oil can be extracted. This oil is used medicinally as a substitute for true almond oil. The seeds are eaten, they are sweet, almond like and used in roasted or raw form (Gunasena, 2007).

Medicinal Uses

The various parts of the tree have shown aphrodisiac activity; hence it could be used for the treatment of some diseases in human, Table provides necessary information on this illness and the necessary treatment. It also contains antibacterial that can be used to improve the lives of aquatic animals (Table 3).

TABLE 3: The medicinal uses of *Terminalia catappa*

S/n	**Parts of the plant**	**Treatments**
1	Young leaves	Dysentery Diarrhoea Gastric fevers Curing of leprosy Scabies Other cutaneous diseases Sudorific Rheumatic joints
2	Seed	Fairly potent to cardidiotonic
3	Bark	Diarrhea Gastric fevers Dysentery Catarrh Skin diseases Heart problems
4	Fallen leaves	Treatment of liver related diseases
5	Decoction of leaves	Vermifuge
6	Flower	Used to induce sterility in human
7	Fruit	The kernel contains aphrodisiac to treat sexual problems. Fruit can be used to maintain good health for aquarium fish especially catfishes, black water tetras and betas

Source: Gunasena (2007)

Ornamental Uses

The commonest use of this tree is as an Ornamental tree. It is cultivated in gardens, parks, and road sides in Nigeria, India, Malaysia, Thailand, Indonesia, Hawaii, Puerto Rico, Sri Lanka and elsewhere because of its unusual whorled branching and leafs colouration (Gunasena, 2007). In Nigeria it is grown as a shade tree in urban areas. As the tree is tolerant to salt, it is grown along the beaches for coast conservation in Sri Lanka.

Wood

The strength properties values in Table 2 shows that *Terminalia catappa* had very close strength values to other terminalia family like *Terminalia ivorensis* and *Terminalia superba* of 85.22 N/mm^2 and 112.0 N/mm^2 respectively that are currently being used for

structural applications (Oriowo *et al.*, 2015, Adeniyi *et al*., 2013 and Okai 2002). Meanwhile, the modulus of elasticity was higher than the previous report by (Oriowo *et al*., 2015, Adeniyi *et al*., 2013 and Okai 2002) for the *Terminalia ivorensis* and *Terminalia superba* of 9443 N/mm^2 and 6,300 N/mm^2. the wood is commonly used for making furniture, veneer, millwork and cabin work. It is also used in general construction (house, boat and bridges ties), furnitures, flooring and boxes and cabinet making and crates (Gunasena, 2010).

Other uses

Bark, leaves, fruits and roots have tannin which is used for tanning purposes, mainly tanning leather and dyeing cloth and making ink (Gunasena, 2007). The foliage is used for silk production and suitable for feeding silkworms (Anonymous 1980)

CONCLUSION AND RECOMMENDATION

The extension of *Terminalia catappa* species to Africa could be of blessing if necessary information on the wood species can be utilized. Apart from shady purpose of terminalia catappa, it also grows better in Nigeria. The medicinal potentials of this species can boost the economic situation of any country if embarked upon. The wood could also be useful in structural applications because it contains better physical and strength properties that could compared favorably with other *Terminalia* species. The government should encourage the plantation of this plant species for economic benefit. Through this initiation, pharmaceutical, wine industries, brewery and wood industries will benefit from the plant products.

REFERENCES

Adeniyi, I.M; Adebagbo, C.A; Oladapo, F.M and Ayetan G (2013): Utilization of Some Selected Wood Species in Relation to their Anatomical Features; Global Journal of Science Frontier Research Agriculture and Veterinary. Vol13 (9) Pp 19 – 24

Anonymous (1980): Firewood crops: Shrubs and tree species for energy production. National Academy of Sciences, Washington DC: 66-67

Anonymous (1995): Plant resources in Southeast Asia (2). Timber trees and minor commercial; timbers. Leiden Backhuys Publishers: 4822-485.

Artuz-Siegel, E.A; Wangard, F.F.and Tamalog, F.N. (1968): Relationship between fibre Characteristics and pulp sheet properties in Philippines hard woods. *Tappi* 51:261-267.

Aktuell, (2007): Meyers Lexikonverlag Mannheim, Leipzig, Wien, Zürich. 125. Corner B (1986): Fungi of Australia. Volume 2 B, Pp 44 – 45

Dessch, H.E and Dinwoodie, J.M. (1991): Timber, Its structure , properties and Utilization, 6th Edition. Published by Macmillan Education Limited. 410pp.

FAO (2006): Global forest resources assessment 2005, Progress towards sustainable forest management by FAO of the United Nations, 350. Rome

Gao, J., Tang, Z., Dou, H., Fan, Y., Zhao, X and Xu, Q. (2004): Hepatoprotective activity of *Terminalia catappa* L. leaves and its two triterpenoids. *Journal of Pharmacology* 56:1449-1455

Gunasena, H.P.M (2007): Kottamba: *Terminalia catappa* L.: Asia pp 437 451http://www.worldagroforestry.org/downloads/publications/PDFs/BCO7328.PDF Vol 328/

Jayaweera, D.M.A. (1982): Medicinal plants (Indigenous and exotic) used in Ceylon. Volume IV. The National Science Council of Sri Lanka, Colombo, Sri Lanka.

Kinoshita, S., Inuoue, Y., Nakama, S., Ichiba, T. and Aniya, T. (2006): Antioxident and Hepatoprotective actions of medicinal herb, *T. catappa* L. from Okinawa Island and its tannin corilagin *Phytomedicine*, Elsevier : 1-7

Kumar D and Gupta R K, (2004): Antagonistics Streptomyces violaceusniger to control wood-rotting fungi, in Biodiversity and natural products: Chemistry and medical applications, conference, held on 26-31 Jan, 2004 (IUPAC International Conference, New Delhi, India), p-161

Larson, P.R.(1969): Wood Formation and Concept of Wood Technology Vol. 1 MacGraw Hill Book Company, New York. 705pp

Lemmens R.H.M.J and Wulijani-Soetjipto (1992): Plant Resources of south East Asian (No 3: Dye and Tannin produce plants (PROSEA hardcover, pp 234)

Masuda, T., Yonemori, S., Oyama, Y., Takeda, Y., Andoh, T., Shinohara, T. and Nakata, M. (1999): Evaluation of the antioxidant activity of environmental plants: Activity of the leaf extracts from sea shore plants. *Journal of Agricultural and Food Chemistry* 47: 1749-1754.

Nagappa, A.N., Thakurdesai, P.A., Venkat Rao, N and Jiwan Singh, (2003): Antidiabetic activity of *T. catappa* Linn fruits. *Journal of Ethno-pharmacology* 88: 45-50.

Okai, R (2002): Fellowship report; ITTO Tropical Forest Update. Pp 1- 12
Oriowo B.T; Amusa, M.A and Aina K.S (2015): Evaluation of mechanical properties of *Terminalia catappa* trees and stems from southwestern Nigeria. *International Journal of Novel Research in Electrical and Mechanical Engineering*, Vol 2, Issue 4, Pp 132-138
Panshin, A.J. and de Zeeuw, C .(1980): Text book of Wood Technology, Structure, Identification, Properties and Uses of the commercial wood of the United States and Canada, McGraw Hill Book Company, New York. 277 pp.
Rauel K & Barnoud F, (1985): Degradation of wood by microorganisms, in Biosynthesis and biodegradation of wood components, edited by T Higuchi (Academic press inc. Floridal) 1985, 441
Record, S. J (2004): The mechanical properties of the wood; including a discussion of the factors affecting the mechanical properties, and methods of timber testing. In. 08-05 004.http://www2.cddc.vt.edu/gutenberg/1/2/2/9/12299/12299-h/12299-h.htm#PREFACE
Rupert, W; Geofery, M.D. and Robert, E..(2002). High- Resolution analysis of radial and wood density in Eucalyptus nitens, grow under different irrigation regimes.
Stace and Clive, A (2002): (1523) Proposal to conserve *Terminalia* nom. Cons. (Combretaceae) aga an additional name, Bucida. *JSTOR*: Taxon 51 (1): 193
Sutton, W.R.J (1999): The need for planted forests and the example of radiata pine. *New Forests* 17: 95-110.
Titmuss, F.H. (1997): Commercial Timber of the World. Second edition, Revised and enlarged, forming the fourth edition of a concise Encyclopedia of World timber. London, the Technical press.
World Resources Institute (1990): Development Report.
Youngquist, J.A. and T.E. Hamilton (1999): Wood products utilization: A call for reflection and innovation. *Forest Products J*. 49: 18-27.
Zobel, B.J. and Jet, J.B.(1995): Genetics of wood production, Springer series in Wood Scienc Bulletin, Heiderbery, New York.

URBAN FOREST AS AN ECOSYSTEM RESOURCE

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ABSTRACT

Urban fforest as an ecosystem is a very versatile environmental resource that primarily provides services rather than goods. These services, to a large extent, can help cities to control some of the physical and socio consequences of urbanization. It is expected that an urban city with adequate and quality vegetative cover will be mmore resilient, sustainable and equitable to mitigate and adapt to climate change process, reduce disaster risk and conserve ecosystems. There is dire need to conserve urban forest ecosystems for continued provision of environmental services both for present and future generations. This paper highlights the benefits of the urban forest with the aim to buttress the need for its continued existence and sustainable management in Nigeria.

Keywords: Urban forest, ecosystem resource, conservation

INTRODUCTION

Urban forest is described as woody vegetation within the environment of populated places that includes all trees owned by public and private entities within an urban area. Urban forests ecosystems are an inherent part of urban areas with diverse elements (i.e. residents, fauna, buildings, infrastructure, water, and air) that relate to provide an essential effect on the quality of life of urban dwellers (Nowak *et al*, 2010). The components of urban forest includes all trees found in parks, roadsides, home gardens, industries, commercial areas, mining areas, transmission lines, flood plains, roof of buildings, academic places, medical centers and religious centers. It is however, expected that the the practice of managing urban forest cover will sustain their social, economic, environmental and ecosystem services (Nowak, *et al* 2010). It is projected that *more than half the global population will live in urban areas, thus, urban and peri-urban forestry is becoming the framework through which people make judgements about all the worlds forest, therefore, we must ensure that urban residents and urban forest resource interact to achieve the need of rapidly growing areas and to communicate the value of ……the urban forest to life (*FAO, 2010).

Urban forest as an ecosystem is a very versatile environmental resource that primarily provides services rather than goods. These services to a large extent, can help cities to control some of the physical and socio consequences of urbanization. It is expected that an urban areas with adequate and quality green vegetation will be more resilient, sustainable and equitable to mitigate and adapt to climate change process, reduce disaster risk and conserve ecosystems (FAO, 2010). From research and experience, the urban forest resource has been attested to provide, throughout their lifespan, a benefit package worth two to three times more than the cost of establishment and management, thus, cities that take steps to invest in greening initiatives are rewarded. (http://www.fao.org/forestry/urbanforestry/en). Therefore, the conservation of the urban forest is a mechanism towards ensuring safe, resilient and sustainable cities through increase in resource efficiency, mitigation and adaptation to climate change process, disaster risk reduction and providing a global access to safe, green urban areas by 2030 (Sustainable Development Goal (SDG 11).

Benefits of Urban Forest Ecosystem

Urban forest ecosystem provides environmental and socio-cultural values in areas where they exist. Management of urban forest ecosystem for provision of environmental services is of utmost importance in cities that are rapidly growing in Nigeria. Hence the understanding of these benefits will contribute to sustainable development of the urban forest to continue to provide these services for present and future needs.

Environmental Service Value

Forests help maintain and improve the environment in different ways. These include:

Climate Amelioration

The major elements of climate that affect us include solar radiation, temperature, air movement and humidity. However, there are comfort zones associated with the interaction of these four elements. There can be situations of too hot, too cold or just right. These can easily be regulated indoors within a building but hypothetically similar controls can be done in the outdoor environment (Grey and Frederick 1978). Trees, shrubs and grasses can ameliorate air temperatures by controlling solar radiation and regulating atmospheric temperatures to create a micro-climate that can produce comfort in urban environments. Studies have shown that the need for air conditioning and energy used for heating have been reduced in areas where buildings are surrounded by trees to about 30% and 20%-50% respectively. Air movement or wind also affects human comfort positively or negatively, depending on the presence or absence of urban vegetation. Where present, they are used as effective wind controllers and to create sheltered zones. Ogigirigi (1986) recorded a wind speed reduction of as much as 30-50% in shelterbelt areas of Northern Nigerian. On the other hand, areas with relatively less trees are exposed to severe winds causing discomfort, irritation and occasionally loss of lives and property. Trees are also important in the hydrologic cycle. They intercept rainfall and slow down its impact to the soil surface causing increased infiltration and decrease in run-off and soil erosion.

Erosion Control

Because of the environmental impact associated with urbanization (i.e land clearing for construction activities), the presence of trees in urban areas is very important for erosion control. Soil erosion is the loss of topsoil by wind or water movement and in urban areas it is usually associated with construction activities where the soil surfaces have been exposed. Forest soil is able to absorb large quantity of rain; tree litter serve as cushion or protective soil cover against direct impact of rainfall and forests also improve soil organic matter content and structure, thus preventing the rapid run-off of water that can lead to erosion and flooding. For example, Hamel *et al* (2006) did an assessment on this function and reported that the impact of rain causes more soil erosion in deforested areas, thus, vegetation establishment will sustain and reduce cost of erosion control methods.

Noise Control

Noise is an unwanted or excessive sound and often referred to by experts in the field as invisible pollution which has both physical (i.e transmission of sound waves through the air) and physiological (i.e. human response to the sound) effects. It affects the hearing mechanism of man depending on the frequency. Propagation of outdoor noise usually depends largely on the nature of the source of the noise, the nature of the terrain and vegetation cover which the sound passes and the state of the atmosphere. Experts have reported the potential of trees for sound reduction. Federer, (1999) affirmed that sound waves are absorbed by leaves, branches and twigs of trees and shrubs because of their light and flexible nature. Wide plantings (around 100 ft) of tall dense trees combined with soft ground surfaces have also been reported to reduce apparent loudness by 50 percent or more (6 to 10 decibels) through their own noise which are pleasant sound that tend to distract us from more offensive noises (Nowak, 2010). Also, plants support animals and birds that may make desirable sounds. Although plants play a major role in sound abatement, they will only reduce noise if used properly.

Air Pollution Control

Trees are effective in reducing gaseous and particulate air pollutants in several ways. Mbakwe, (1992) informed that the leaves and stomata of trees can absorb gaseous compounds (smoke) and airborne particulate matter (sand, dust) generated by environmental metabolic activities, this is particularly observed where trees are planted adjacent to factories or along untarred roads. Research has also shown that a productive and well managed urban forest canopy cover can modify air quality and can help assist a city to attain clean air standards (Nowak, *et al* 2006). This is especially important for urban areas with the challenge of meeting air quality standards. Trees are capable of removing a combination of pollutants (nitrogen dioxide (NO2), sulphur dioxide (SO2), ozone (O3), carbon monoxide (CO), and particulate matter (PM10)) from the air. Urban trees in the United States have been reported to remove about 784,000 tons of air pollution per year, with a value of $3.8 billion (Nowak *et al*. 2006). This is highly significant and cost-effective method for the control of air pollution in a city.

Enjoyment Value

The urban forest offers a special source of enjoyment through its natural beauty and peaceful atmosphere and a plenty of other benefits to urban dwellers. It has been reported that spending time near trees has the tendency to improve physical and mental well-being by boasting energy and recovery levels, while decreasing blood pressure and stress. Heisler, *et al* (1995) affirmed that the urban forest is important in this aspect as its trees provide shade (Fig I) that can reduces ultraviolet radiation and its associated health problems and also provide suitable settings for people to think and reflect, evoke memories and commune with nature. In the United States, Canada, and many other countries, huge forestlands have been set aside for urban residents to engage in camping, hiking and hunting activities while some others only visit them to relax and enjoy the quiet scenery (Grey and Frederick, 1978). In most cases these benefits are taken for granted especially when the urban dweller is ignorant of these benefits hence urban forestry as a science aims to increase and preserve these benefits by careful management of urban forest landscape.

Aesthetic Value

Urban forests in the environment can provide an aesthetic, enjoyable, and emotionally comforting place where people live, engage in productive activities and spend time to relax (Taylor *et al*. 2001a, 2001b). Trees are aesthetic elements in our surroundings that are beautiful because of their lines, forms, colours and textures (Plate1). They are dynamic giving different appearances in the changing seasons and throughout their life span. They provide movement and pleasant sounds through the rustling of their leaves and the whistle of wind through a canopy. The proper placement of trees in urban environment can make scenic views more spectacular because of the window effect they create. (Hartig, *et al,* 2003; Van den Berg, *et al.* 2003). Faleyimu (2014) reported that people love to plant trees around their houses beautify their surrounding environment since they love to live and work in a green environment (Fig I). Trees enhance the environment in which urban wildlife live as they are useful for the berries, nuts and shelter they provide to birds and animals, and this provide a scenic and aesthetic view in the urban environment. It is generally believed and obvious that nature is beautiful, hence people hardly take time to reflect on it. Also, experts have paid no or less attention to this topic because there was no need to confirm the obvious or to justify this phenomenon. However, research interest in this area became necessary when the aesthetic services of urban forest were being threatened by the continuous expansion in cities and that these values need be protected in their own right (Piana and Troxel 2014).



Plate 1: The shade of trees keep people and the environment cool (Faleyimu, 2014)

Threat to the Urban Forest

Urbanization is defined as the collection of people in relatively large number at a specific spot of the earth (Olotuah and Adesiji, 2005). Angotti, (1993) reported the statistics that showed over half of 6.6 billion people occupying 3 percent of the total global land area, now living in urban areas. This proportion which was less than 5 percent in 1800 has increased to 47 percent in 2000 and expected to reach 65 percent in 2030 (United Nations, 2000). In Nigeria, it is projected that the number of people living in urban area will be about 100 million by 2020. (Oyeleye, 2013). Also, more than 7 billion people populated the Earth in 2011 with the richest countries contributing significantly to this increase; however, currently most of the growth is occurring in less developed countries, especially in the African and Asian regions where urban growth is expected to double the 2000's urban population figures by 2030. The National Population Commission (2006), census figure placed Nigeria as the sixth most populated nation in the world after China, India, USA, Indonesia and Brazil, with 167 million persons. Presently, Nigeria has an estimated population of about 170million people making her the seventh largest and most rapidly growing country in the world (National Bureau of Statistics, 2016). Due to intense rural-urban migration resulting in upward surge of people into urban center, more than half of this population now live in urban areas. Between 1950 and 1991, the estimated percentage of people living in urban areas was 35%. Since the emergence of ancient cities such as Benin, Kano and Zaria between the 14th and 17th century, there has been a steady evolution and multiplication of urban centers (Oyeleye, 2013).

Urbanization has resulted to adverse effect on the urban forest as it brings about competition for forest land for developmental purposes. Forest land areas are converted for urban uses, or for meeting the demand for fuel and building materials. Baur, *et al* (2016) reiterates that population growth account, in part, for the rapid physical expansion of cities which no doubt will produce direct and significant impacts on forest resources. In a related study on the impact of urban emergence on forest land, it showed the extent of destruction to have resulted from a high rate of physical expansion due to housing and infrastructural development (*Konijnendijk, et al 2004a)*. Rapid housing and infrastructural development is necessitated to meet the demands of the ever increasing population and this usually takes place without any real land use planning causing highly damaging effects on forested landscapes, as well as other tree resources and green areas in and around cities.

Konijnendijk, et al (2004a, 2004b) stated that the environmental impacts of urbanization create greater issues for urban dwellers and it is estimated that 60 per cent of urban dwellers are living in areas of high risk of exposure to at least one natural hazard with flooding and drought as the most frequent. Ultimately, degraded green resources and related urban environmental hazards can lead to: landscape fragmentation; higher frequency and vulnerability to extreme weather events such as floods, droughts, landslides and extreme winds; vulnerability of soil to erosion and watershed degradation; heat island effect; increase of the economic costs in terms of mitigation of climate change effects; increasing levels of pollution and increase of human diseases (such as cancer, cardiovascular diseases, allergies, obesity). These consequences are greatly felt in developing countries including Nigeria and contribute to increased economic and social degradation in and around cities, hence, urban forestry issues are needs to be placed on priority list of decision-makers to promote sustainability.

Some Environmental Consequences of Urban Forest Removal

Forest and Climate

Atmospheric carbon dioxide ($CO_{2)}$ is trapped, absorbed and stored as wood or soil carbon by trees. However, when forest is cleared and burnt for agricultural purposes or exploitation for timber and fire wood, CO_2 is released to the atmosphere in large quantities. This phenomenon leads to a continuous increase in temperature globally causing changes in climate and weather conditions. Odjugo (2011) reported that Nigeria is experiencing global warming with a temperature increase of 1.78^0C from 1971 to 2008, and this rate is higher than the global mean temperatures of 0.74^0C. This sharp increase in temperature in Nigeria could be related to the outcome of climate change and global warming (Mabo, 2006). Climate change in urban areas results from the high rate of developmental activities (industrial and commercial) with little or no consideration of the environmental implications. The consequence of this increase in sun radiation is incessant harsh temperature that could pose more threat to human body causing many disease outbreak (skin reactions and respiratory diseases) among others (Oyeleye, 2013).

Forest and Rainfall

The relationship between forest and rainfall shows that an abrupt upward movement of air over forest can induce the building up of cloud and initiate rain (Proctor, 1985). Forest is very effective than other vegetation types to trap other kinds of precipitation such as fog and moisture. Thus, rainfall has declined in many deforested parts of tropical Africa (FAO, 2010). A decrease in rainfall over time has also led to droughts and this has contributed to decline in agricultural and livestock production and abandonment of settlements, for example in northern Nigeria, Sudan and Sahel regions.

Forest and Soil Erosion

Research studies have shown that soil erosion is higher in areas with little or no vegetative cover (Plate 2). However, the relationship between deforestation and soil erosion is difficult to measure and largely depends, among other things, on land-use pattern, location and annual rainfall (Boahene, 1998). Adetunji and Oyeleye, (2013) affirms that excess floods and erosion (Fig II) could be a future problem of urbanization that may claim more lives in the future.

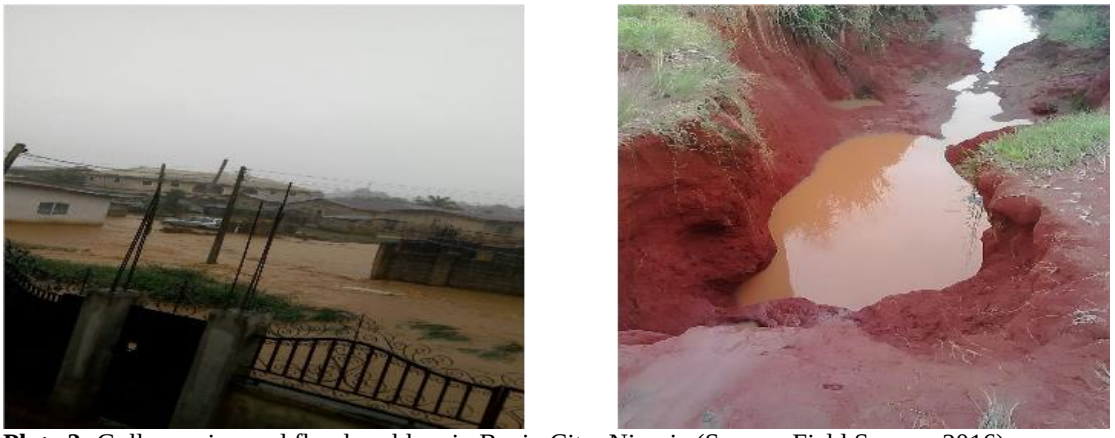


Plate 2: Gully erosion and flood problem in Benin City, Nigeria (Source: Field Survey, 2016)

Way Forward

Urban forest as a public, non-rival and non-excludable resource that offers a variety of environmental services is gradually been lost in Nigeria. There is therefore a dire need for more effective and sustainable management of this very essential resource. The approaches are therefore recommended to contribute to sustainable management of this very important resource.

Adopt training initiatives

In developed countries, over the past three decades, forest resource managers, scientists and experts in environmental conservation have designed and implemented plans to expand both the science and management of the urban forest (Georgia, 2013), hence, scientists and experts in the field of urban forest research in Nigeria can take the initiative to learn various processes and adopt them in the management of urban forest in the country.

Recognize urban forest benefits

Recent trends to describe the urban forests as a green infrastructure is determined through identification and valuation of ecosystem services and the immense benefits (both direct and indirect) that people can obtain from a composition of environmental service functions (Puspam, 2010), hence, our perspective on urban forests needs to change and develop to remind us of the need to see the prospects of the urban forest ecosystem in Nigeria.

Encourage community participation

Community participation in tree planting (Plate 3), will drive sustainable urban forest management both now and in future. Community forestry and public participation in tree planting programs have been related to sustain benefits for urban residents. Active involvement in tree-planting programs will enhance a community's sense of responsibility to cater for their environment as residents become more responsive to work together, dictate and control the state of their environment. Planting programs can also serve as a visible sign of change and provide the driving force for other renewal and active programs in the community (Feldman and Westphal, 1999).



Plate 3: Community participate in tree planting and care in Cross River, Nigeria

Urban greening programs

The science of urban forestry can be an important tool to finding solutions to the continued decline in vegetative cover of urban forest across cities in Nigeria through the enhancement of urban greening programs, sustainable management plans, and concise goals and objectives for development of urban forests. This is important since majority of the cities in Nigeria are fast urbanizing with increase in population of people living in urban areas.

CONCLUSION

This review has highlighted some of the benefits that can be derived from the urban forest, thus, it is expected that this would drive the need for conservation of this important resource in Nigeria. Urban forest are of great importance to people especially for their environmental values while at the same time playing an important role to preserve the identity and distinctive character of cities, A clear understanding of the threats to urban forests resulting from continued urbanization and management efforts can help sustain this important resource. Therefore, preserving existing trees and replacing removed ones is essential for both present and future generations.

REFERENCES

Adetunji, M. A. and Oyeleye, O. I. (2013). Evaluation of the Causes and Effects of Flood in Apete, Ido Local Government Area, Oyo State, Nigeria. *Journal of Civil and Environmental Research.* 3(7):19.

Angotti, T (1993). "Metropolis 2000: Planning, Poverty and Politics", *London, Routledge* United Nations.

Baur, J. W.R., Tynon, J.F., Ries, P and Rosenberger, R.S (2016). Public Attitudes about Urban Forest Ecosystem Services Management: a case study in Oregon Cities. *ElsevierJournal of Urban Forestry and Urban Greening*, 17:42–53. http://dx.doi.org/10.1016/j.ufug.2016.03.012.

Faleyimu, O. I (2014). Public Perceptions of Urban Forest in Okitipupa Nigeria: implication for environmental conservation. *Journal of Applied Science and Environmental Management*. 18(3):469-478.

Federer, C.A (1999). Trees modify the urban microclimate. *Journal of Arboriculture*. 2:121-127.

Feldman, R. M and Westphal, L. M (1999). Participation for empowerment: the greening of a public housing development. *Places.* 2:34-37.

Food and Agricultural Organization (2010). Timber Harvesting and the Problem of Deforestation. *FAO Forest Harvesting Bulletin*. 4 (1): 1-3.

Georgia ,S.S (2013) "Mainstreaming the environmental benefits of street trees". Urban Forestry and Urban Greening. 12(1): 2-11.

Grey, W.G and Frederick, J.D. (1978). Urban Forestry, eds Eugine Patti, John Wiley and Sons Inc. 1-119.

Hartig, T., Van den Berg, A., Hägerhäll, C., Tomalak, M., Bauer, N., Hansmann, R., Ojala, A., Syngollitou, E., Carrus, G., van Herzele, A., Bell, S., Podesta, M.T.C., Waaseth, G (2003). Health benefits of nature experience: psychological, social and cultural processes. In: Nilsson, K., Sangster, M., Gallis, C., Hartig, T., Vries, S., Seeland, K., Schipperijn, J. (Eds.), Forests,

Trees and Human Health. Springer, New York, NY. 127–168.
Heisler, G.M.; Grant, R.H.; Grimmond, S.; Souch, C. (1995). Urban forests:cooling our communities? In: Kollin, C., Barratt, M., (eds). *Proceedings of the 7th International Urban Forest Conference.* Washington, DC: American Forests. 31-34.
Konijnendijk, C.C., Gauthier, M., Van Veenhuizen, R. (Eds.) (2004a). Trees and cities growing together. Urban Agricultural Management. 13:1–5.
Konijnendijk, C.C., Sadio, S., Randrup, T.B., Schipperijn, J.(2004b). Urban and peri- urban forestry in a development context – strategy and implementation. *Arboricultural Journal*. 30:269–276
Mabo C.B. (2006). Temperature Variation in Northern Nigeria between 1970 and 2000. *Journal of Energy and Environment*. 19 (1):80-88.
Mbakwe, R. (1992). Prospect of Recreational Forest in Nigeria. *Proceeding of the Annual Conference of Forestry Association of Nigeria*. 36-39.
Nowak, D.J., Stein, S.M., Randler, P.B., Greenfield, E.J., Comas, S.J., Carr, M.A and Alig, R.J (2010). Sustaining America's urban trees and forests: a Forests on the Edge report. U.S. Department of Agriculture, Forest Service, Northern Research Station. 27.
Odjugo, P.A. (2011). Climate Change and Global Warming: The Nigerian Perspective. *Journal of Sustainable Development and Environmental Protection*. 1(16): 6-17.
Ogigirigi, M.A. (1986). Deforestation: Its Impact on the Environment in Oguntala (ed). *Proceedings of the Annual Conference of Forestry Association of Nigeria.* 34-46.
Olotuah, A.O. and Adesiji, O.S. (2005). Housing Poverty, Slum Formation and Deviant Behaviour". Federal University of Technology, Nigeria and 61 Glimpsing Green, Erith Kent, DA 18 4HB London.
Oyeleye, O.I (2013). Challenges of Urbanization and Urban Growth in Nigeria. *American Journal of Sustainable Cities and Society.* 2(1):79-95.
Piana, M and Troxel, B (2014).Beyond Planting: An Urban Forestry Primer.*Scenario 04:Building theUrban Forest*
Puspam, K (2010*). The Economics of Ecosystems and Biodiversity: ecological and economic foundations. UNEP/Earthprint.*
Taylor, A.F., Kuo, F.E and Sullivan, W.C (2001a). Coping with ADD: The surprising connection to green play settings. *Environment and Behavio*r. 33(1):54-77.
Taylor, A.F., Kuo, F.E and Sullivan, W.C. (2001b). Views of nature and self-discipline: evidence from inner city children. *Journal of Environmental Psychology*. 21: 49-63.
Van den Berg., A.E., Koole, S.L and van der Wulp, N.Y (2003). Environmental preference and restoration: (How) are they related? *Journal of Environmental Psychology*. 23:135–146

Contigent Valuation Based Estimation of Agodi Gardens and Park, Ibadan, Oyo State, Nigeria

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ABSTRACT

The failure of the market to fully reflect the value of the social and environmental service function of forest resources has misguided decision maker to under value the forest resources and has led to the giving of priority to other land uses against forestry development. Thus it is important to estimate the economic value of Agodi garden so as to bring forth its importance to decision maker in monetary term and subsequently encourage and hence justify its conservation. Primary data needed for the study were collected through the administration of questionnaires to the residents in Ibadan metropolis. 440 questionnaires were administered to the respondents and 402 were retrieved. Contingent valuation and logistic regression analysis were used to analyze the data. The result shows that individuals are most willing to pay ₦500 to support conservation of the park. The estimated value of the park was ₦1,600,000,000 (One billion six hundred million). The logistic regression shows that age, gender, educational qualification, monthly income, marital status and awareness of the park variable were not statistically significant. This implies that they do not have any meaningful influence on the decision of the respondents to support the conservation of the park. Only the variable "need for the park" was statistically significant which means the odds that respondent will be willing to support conservation of nature park in Ibadan based on their perceived need for the park is about 17.9 times more than those that will not be willing to support conservation of the nature park.

Keyword: Contingent valuation, Agodi garden and park, estimation, willingness to pay

INTRODUCTION

Forest resources are recognized to have a number of values including intrinsic, economic, cultural and aesthetic value. Forest being very versatile environmental resources provides diverse goods and services. Forest services can be viewed from two perspectives, social and environmental. The former consists of that part of the forests environment that provides such services as outdoor recreation, wildlife gaming and viewing and space for spiritual activities. The latter borders primarily on the provision of life support requirement for human beings such as enhancement of watershed management, mitigation of global warming, reduction in air pollution. This forest services are often referred to as public goods and services (Popoola and Ajewole, 2002). This goods and services are enjoyed by all individual yet there is no effective mechanism for allocating them. Economics as the study of how to allocate limited resources relies on valuation to provide society with information about the relative level of resource scarcity (The Economic of Ecosystem and Biodiversity (TEEB) 2010). Valuation plays an important role in creating markets for the conservation of ecosystem services (Kontoleon and Pascual 2010). It can be defined as appraising or estimating the worth of something having economic or monetary value. There are wide ranges of existing economic valuation approaches used in estimating the value of ecosystem services. There are generally two main branches of economic valuation for public goods and services. They are revealed preference approach and stated preference approaches (TEEB 2010).

Revealed preference methods are approaches that are based on market prices. These methods quantify the influence of preference for non- market goods or services on the actual market for other goods hence preference method utilized an individual demand for private good to infer their demand for public goods (Pearce et.al. 2006). The limitation of revealed preference method is that its covers only use values of the analyzed goods and inadequacy of data .Travel cost and hedonic prices are the two different method of this approach. Travel-cost method uses recreation expenditure and travel time to impute the value people place on visiting a specific site (such as a national park. Hedonic pricing method attempts to isolate the influence of non-market attributes (like proximity to parks or landfills) on the price of goods such as houses (Rusche *et. al.* 2013).

Stated preference approaches are survey based involving the use of questionnaire. As a result a market and demand for eco-system services is simulated revealing willingness to pay (WTP) or willingness to accept (WTA) for hypothetical changes in the provision of ecosystem services (TEEB 2010). Stated preference approach includes contingent valuation method and choice modeling. The Contingent Valuation Method (CVM) is a stated preference method in which survey respondents are confronted with a hypothetical scenario that involves a choice between alternatives with different costs or benefits. Despite different ecosystem services provided to the society, the natural resources are often underestimated in terms of their contribution to local and regional economic and social development (Mohammed et. al, 2013). To date, no known economic valuation has been carried out on Agodi garden. Therefore there is need to estimate the non-use value of the park. This paper aimed to estimate the non-use value of Agodi garden and park using contingent valuation method and to determine willingness to pay of non visitors in Ibadan metropolis to support conservation of the park.

METHODOLOGY

Study Area

Agodi garden is situated near the Oyo state secretariat complex, Nigeria (Figure 1).. The geographical coordinates are Latitude: 7°24'32.8" and Longitude: 3°54'0.53" (Omonona, 2015). It stands out as a green lung in the surrounding urban landscape with a great recreational potential. It equally contains an indigenous forest, lake, tree plantation, and an abundant of medicinal plants and some rare tree species. The garden was established as a biological and relaxation centre to provide recreational as well as educational services for inhabitant and visitor in 1956. In 1967 she lost her glory as a foremost centre particularly following its destruction by the famous 1980 flood disaster dubbed Omiyale that swept through the ancient city (Durojaiye, 1983). Agodi garden of Oyo state has been completely renovated to contain a zoo, swimming pool, bar and restaurants (Wikipedia 2014).

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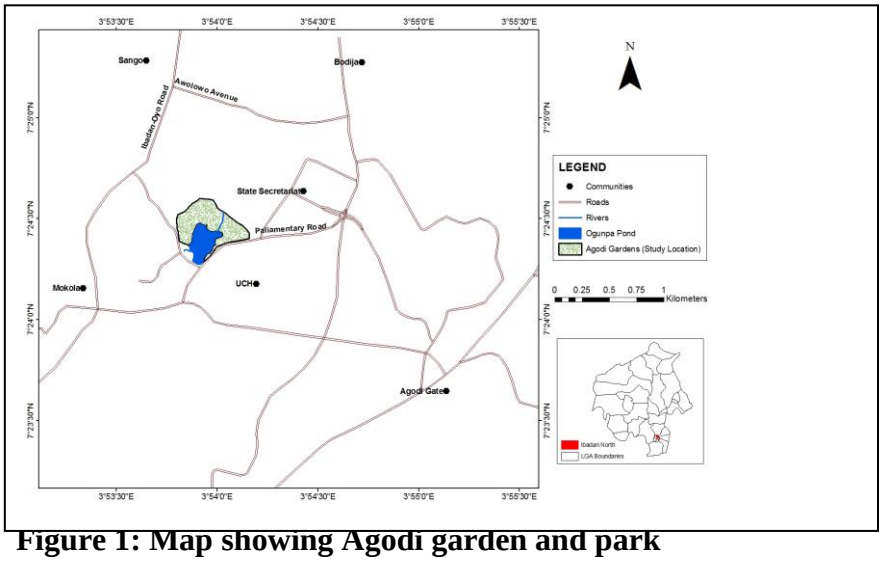


Figure 1: Map showing Agodi garden and park

Sampling Procedure

Primary data needed for this study were collected through the administration of questionnaires to the residents in Ibadan metropolis. Four wards were randomly selected from each of the eleven (11) local government areas in Ibadan metropolis. One street was randomly selected from each of the 4 wards and 10 respondents were also randomly selected from each of the 44 streets. A total of 440 copies of questionnaire were administered. However, only 402 copies were retrieved and used for this study.

Method of Data Analysis

Statistical and econometric methods were used in the analysis of the data collected. Contingent valuation method (CVM) were used to measure both the used value and non-used value while Logit regression was used to determine factors that influences willingness to support conservation. To determine the monetary estimate value of the respondents, the following computational procedure were employed.The mean of the respondent willing to pay (WTP) for the support of the conservation of the park were estimated by the formula:

$$W = \sum fx / \sum f$$

Where
W = mean WTP
∑ = summation
f = frequency of occurrence
x = different value

Logistic regression analysis was used to determine factors that influences willingness to support conservation of the park

$LnY = \alpha + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \beta_6X_6 \ldots\ldots\ldots\ldots..\varepsilon_I$
α = The intercept ,this refers to the value of Y when X is zero
β = The slope, the rate of change in Y for a one unit change in X
Y = dependent variable (Willingness to support conservation)
X = Independent variables
X_1 =Age
X_2 = Gender
X_3 = Educational Status
X_4 = Marital Status
X_5 = Monthly Income
X_6 = Park Awareness
X_7 = Need for Park existence

RESULTS AND DISCUSSION

Table 1: Respondents' willingness to contribute for research and educational use of Park

Amount	**Frequency**
₦100	93(23.1)
₦500	98(24.4)
₦1000	89(22.1)
₦5000	55(13.7)
Above ₦5000	13(3.2)
Total contributors	348(86.6)
Non- contributors	54(13.4)**402**
Total	

Values in parenthesis are percentages

The result in Table 1 shows that 86.6% are willing to contribute towards research and educational benefits of the Park out of which 24.4% are willing to contribute maximum of ₦500, while 3.2% are willing to contribute above ₦5000.

Table 2: Percentage contribution for future use

Amount (₦)	**Frequency**
₦100	107(26.6)
₦500	93(23.1)
₦1000	89(22.1)
₦5000	36(9.0)
Above ₦5000	13(3.2)
₦200	2(0.5)
Total contributors	**340(84.6)**
Non-contributor	**62(15.4)**
Total	**402**

Values in parenthesis are percentages

The result in Table 2 revealed that 84.6% are willing to contribute for future use benefit out of which majority (26.6%) are willing to contribute ₦100 while 3.2% are willing to contribute above ₦5000.This indicate that people do appreciate nature.

Table 3: Percentage contribution of the satisfaction that present generation will have access to nature

Amount	Frequency
₦100	84(20.9)
₦500	87(21.6)
₦1000	43(10.7)
₦3000	34(8.5)
₦5000	1 (0.3)
Above ₦5000	16(3.9)
Total Contributors	340(84.6)
Non-contributors	62(15.4)
Total	402

Values in parenthesis are percentages

The result in Table 3 shows that 84.6% of the respondents are willing to contribute to ensure that present generation will have access to nature of which majority (21.6%) of them are willing to contribute ₦500 and (3.9%) are willing to contribute above ₦5000. From the table above it is revealed that people attached great important to green environment.

Table 4: Percentage contribution of the satisfaction that a species or ecosystem exist

Amount	Frequency
₦100	69(17.1)
₦500	70(17.4)
₦1000	116(28.9)
₦3000	36(9.0)
₦5	1 (0.3)
Above ₦5000	15(3.7)
Total Contributors	307(76.4)
Non-contributors	95(23.6)
Total	402

Values in parenthesis are percentages

The result in Table 4 revealed that 76.4% of the respondents are willing to contribute to the satisfaction that a species or eco-system exist of which majority of the respondents (28.9%) are willing to contribute ₦1000 and 3.7% are willing to contribute above ₦5000.This indicates that people appreciate wildlife and eco-system and are most particular about preventing the extinction of the eco- system.

Table 5: The average individual willingness to pay and the Mode total willingness to pay.

Non used value	Individual average willingness to pay (₦)	Mode value of willingness to pay (₦)
Research/educational	1321.26	500
Future use benefit	1049.27	100
Knowing that future generation will benefit	1219.77	500
Present generation benefit	1122.57	100
Knowing that a species/ecosystem exist	1222.54	500
Total	**5935.38**	

From table 5, the mode value (amount individuals are most willing to pay) is ₦500
The Non- use value = Mode value willingness to pay × the general population (Ibadan NPC 2006)
= 500 × 3,200000
= ₦1,600,000,000

This findings support that of (Poopola and Ajewole, 2002) who recorded an aggregate estimate value of 155.5 and 240.9 million naira as the amount residents of Ibadan are willing to pay for environmental services of Ibadan forests. In essence residents are willing to pay for the support of the conservation of the park.

Table 6: Logistic Regression Analysis of Determinants of Willingness to Support the Conservation of the Park

	B	S.E.	Wald	Df	Sig.	Exp(B)
Age	-.046	.062	.534	1	.465	.955
Gender	-.280	.740	.143	1	.705	.756
Education	.406	.513	.625	1	.429	1.500
Marital status	.170	.292	.339	1	.561	1.185
Monthly income	.000	.000	.939	1	.332	1.000
Park awareness	-18.636	2.838E4	.000	1	.999	.000
Need for park	2.886	1.319	4.789	1	.029*	17.928
Constant	-.773	2.212	.122	1	.727	.461

* Significant at 5% probability level

From the logistic regression result (Table 6), age, gender, educational qualification, monthly income, marital status and awareness of the park variable were not statistically significant. This implies that age, gender, education, marital status, monthly income and awareness of respondent of Agodi Park do not have any meaningful influence on the decision of the respondents to support the conservation of the park. Only the variable "**need for the park**" was statistically significant. This means that the odds that respondents will be willing to support conservation of nature park in Ibadan based on their perceived need for the park is about 17.9 times more than those that will not be willing to support conservation of the nature park.

CONCLUSION

The study has clearly revealed that out of various variables examined for respondents' willingness and decision to support the conservation of the park, only their perception of the need for the establishment of the park was statistically significant. This implies that the people value the existence and important of park in the study area.

RECOMMENDATION

It is therefore recommended that appropriate measures be put in place to safeguard the park and prevent it from degradation and sustain its continuous use to serve the interest of the people in the study area.

REFERENCES

Durojaiye, B. O. (1983). Estimating Potential Monetary Benefits from Quality Improvement of Recreation Centre: The case of Agodi Gardens, Ibadan, Nigeria. *The Nigerian Journal of Forestry*. 13(1 and 2): 87 – 90

Herath, G. (2004) Estimating the Economic Value of Mount Buffalo National Park with the Travel Cost and Contingent Valuation Models. Tourism Econ. 10(1):63-78

Kontoleon, A. and Pascual, U. (2007). Incorporating Biodiversity into Integrated Assessments of Trade Policy in the Agricultural Sector. Volume II: Reference Manual. Chapter 7. Economics and Trade Branch, United Nations Environment Programme. *http://www.unep.ch/etb/pdf/UNEP%20T+B%20Manual.Vol%20II.Draft%20*June07.pd.

Luke, O. O and Olusola, S. O (2011) .Valuation of recreational benefit of old Oyo National park Nigeria, A travel cost method. *Journal of Food Agriculture and Environment* 9(1):521-525

Mohammed, E. Abedellatif, M. and Faical, B. (2013) An Economic Assessment of the Ramsar Site Massa (Morocco) with Travel Cost and Contingent Valuation Methods. *African Journal of Environmental Science and Technology* Vol. 7 (6) 414 - 447

Omonona, A. O. (2015) Development of Agodi Park and Gardens: Challenges and The Way Forward. PAT June 2015; 11(1) : 117-129 *www.patnsukjournal.net/currentissue*

Popoola, L and Ajewole, O. (2002): Willingness to Pay for Ibadan Urban Environment Rehabilitation through Reforestation Projects. *The International Journal of Sustainable Development and World Ecology, 9:256 -268.* (U.K.)

Rusche K., Wilker J., Blaen P. and Benning A. (2013) Overview of existing economic valuation methods to capture ecosystem service benefits of quarry restorations. Restore - Work Package 4, Action 21. *https://www.google.com.ng/url?sa=t&rct=j&q=&esrc=s&source=web&cd=8&cad=rja&uact=8&ved=0ahUKEwihs8emtbfPAhUCCpoKHaTUAcIQFghEMAc&url=http%3A%2F%2Fwww.restorequarries.eu%2Fdownload%2Fi%2Fmark_dl%2Fu%2F4012156712%2F4599102625%2FEconomic%2520Valuation_ILS_draft.pdf&usg=AFQjCNFbz4237rGsWY514EV0QcbnqS-9eA&sig2=DkYGxBMMO89-Hhao3eNRHA&bvm=bv.134495766,d.bGg. Accessed September 30, 2015*

TEEB Document (2010). The Economics of Ecosystems and Biodiversity for National and International Policy Makers. pp20. *http://www.teebweb.org/wp-content/uploads/2013/04/D0-Chapter-5-The-economics-of-valuing-ecosystem-services-and-biodiversity.pdf* . Accessed September 29 2015

Wikipedia (2014). https://en.wikipedia.org/wiki/Agodi_Gardens

Climate Change Awareness among Secondary School Teachers in Ibadan

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ABSTRACT

Climate change is a topical issue worldwide because of its attendant problems that are threatening the sustenance of man and his environment. These are particularly becoming more severe in the underdeveloped and developing countries of which Nigeria is one. It has become a reality, with grievous consequences. The impact of climate change includes floods, landslides, drought and famine. As weather becomes fiercer and storms increase in frequency and intensity, serious socio-economic consequences are expected. Malnutrition and disease become common occurrences. Despite these multi-various impacts of climate change, the biggest obstacle is the lack of its awareness and knowledge and that people need to be educated and be informed about it. Secondary school, was therefore the focal point and since climate change is not restricted to any particular discipline, gender, academic qualification, age , marital status, teachers were interrogated to know how much of climate change they know in other to tackle the problems which man is facing in his environments. This paper assesses the knowledge of teachers on environmental awareness in some selected secondary schools in Ibadan metropolis.

Keywords: Awareness, climate change, secondary school teachers.

INTRODUCTION

Climate change, or global weather patterns, or global warming can be described as the biggest environmental issue of our time. It is global in its causes but its consequences are far more reaching in developing countries, particularly Nigeria. It is a topical issue worldwide because of its attendant problems that are threatening the sustenance of man and his environment. These are particularly becoming more severe in the under-developed and developing countries (Small and Nicholis, 2003). Climate change has become the new reality of our time which brings with it changes in weather patterns that can have serious repercussions for human beings, upsetting seasonal cycles, harming ecosystems and water supply, affecting agriculture and food production, causing sea-levels to rise. Climate change has a cumulative effect on natural resources and the balance of nature. Its effects are already visible in Nigeria.
Nigeria, as a developing nation is particularly sensitive to the effects of climate change. A large part of the economy of the country depends on natural resources, which are particularly vulnerable to climate change. When those resources are affected, communities are implicated. Disease, loss of livelihoods and settlements can force entire communities into relocation or complete extinction and even refugee status. As critical as the effect of climate change is, it is not clear whether Nigerians are aware of what climate change is or its effects. Olorunfemi (2010) opined that the biggest obstacle is the lack of awareness and knowledge. There is need for people to be educated and informed about climate change and how it can change our lives drastically. Lack of information (awareness) and knowledge (education) about climate change also means that many people are reluctant to accept the reality of climate change. Also, there is a lack of public policy, government preparedness and commitment to promoting climate change adaptation strategies in the country. The teacher is the key to the whole teaching-learning process in Environmental Education. It is necessary to redefine the role of teachers. A teacher's role is not that of transferring information but of being a facilitator, a leader and a resource person. The teachers' role in environmental education should be; to bring an awareness to protect the environment; to make each child an agent to conserve the environment (Khan, 2006). This paper therefore examined the awareness of climate change among secondary school teachers and its effects on the people and the challenges.

METHODOLOGY

Study Area

Ibadan is located between 7^0 26' North and 3^0 54' East in south-west Nigeria. It is the capital of Oyo State, and is reported to be the largest indigenous city in Africa, south of the Sahara. Its population is estimated to be about 3,800,000 and the largest metropolitan area in Nigeria by population after Lagos and Kano according to 2006 estimates. The principal inhabitants of the city are the

Yoruba's. The central metropolis of Ibadan, south-west Nigeria, covers an area of 128 km2 (NBS, 2006) and is one of the largest cities in West Africa. A large number of people in Ibadan engage in agriculture and other economic activities including public service employment and trading (Fourchard, 2003).

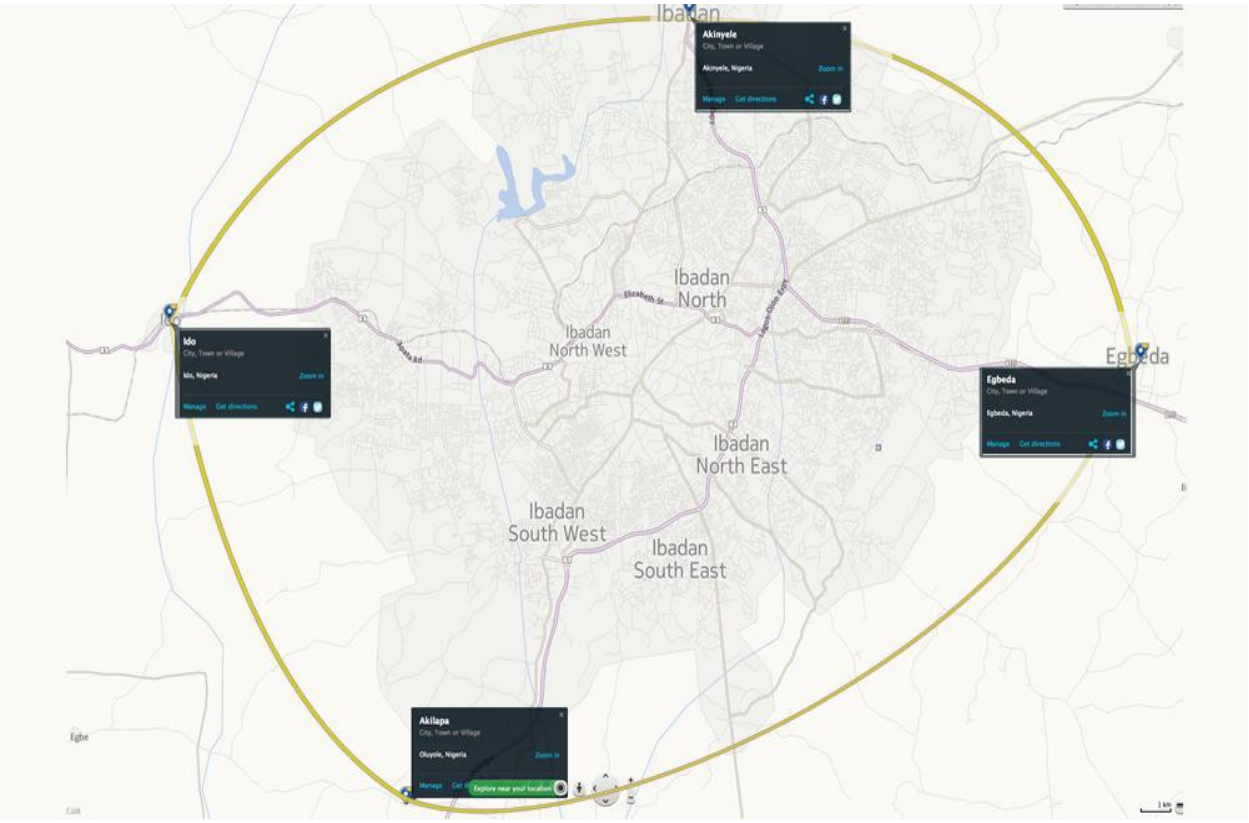


Figure 1: Study Locations

Data Collection and Procedure

Multistage sampling technique was employed to investigate the level of environmental awareness, among secondary school teachers. A total number of 300 questionnaires were administered in the three local governments, Ibadan, namely: Ibadan North local government, Ibadan South west and Akinyele local government Ibadan.
Ten teachers were administered to in each of the Five Public and Five Private Schools of the three local governments. Questionnaires were distributed based on data related to the teachers' awareness. The questionnaires were distributed and collected through the school principals and heads of departments. To avoid any vocabulary problems in the data collection and conceptual misunderstanding, discussion was made on the questionnaire with the respondents to ask for clarification. Data for the study were collected with the aid of structured questionnaire from 188 respondents using the simple random sampling technique. Data collected were analyzed using descriptive statistics.

RESULTS AND DISCUSSION

Socioeconomic Characteristics

In table 1 below, gender's response is quite impressing; this is because there is need for all to be aware about climate change for obvious reasons. The UN Women Watch opined that women are more vulnerable to the effects of climate change than men—primarily as they constitute the majority of the world's poor and are more dependent for their livelihood on natural resources that are

threatened by climate change. Furthermore, they face social, economic and political barriers that limit their coping capacity. Women and men in rural areas in developing countries are especially vulnerable when they are highly dependent on local natural resources for their livelihood. Those charged with the responsibility to secure water, food and fuel for cooking and heating face the greatest challenges. Secondly, when coupled with unequal access to resources and to decision-making processes, limited mobility places women in rural areas in a position where they are disproportionately affected by climate change. It is thus important to identify gender-sensitive strategies to respond to the environmental and humanitarian crises caused by climate change.

Table 1: Socioeconomic characteristic

Characteristics	Variables	Frequency (n = 188)	Percentage
Sex	***Male***	96	51.1
	Female	92	48.9
Age (yrs)	***20 – 30***	67	35.6
	31 – 40	70	37.2
	41 – 50	43	22.9
	51 – 60	7	4.3
Marital status	***Married***	108	57.4
	Single	74	39.4
	Others	6	3.2
Educational Qualification	***WAEC***	2	1.1
	NCE	17	9.0
	OND	6	3.2
	HND	19	10.1
	BSC	108	57.4
	MSc	23	12.2
	PhD	2	1.1
	Others	11	5.9
Area of specialization	***Commercial***	43	22.9
	Arts	49	26.1
	Sciences	81	43.1
	Languages	15	7.9
Years of teaching experience	***1 – 5***	102	54.3
	6 – 10	32	17.0
	11 – 15	28	14.9
	>15	26	13.8
School curriculum has environmental issues	***Yes***	154	81.9
	No	34	18.1

Teachers' Response on Climate Change

Table 2 indicated that 58% showed much concern for climate change and the reason is not far-fetched in that the effect could be disastrous which includes frequent drought, increased environmental damage, increased infestation of crop by pests and diseases, depletion of household assets, increased rural urban migration, increased biodiversity loss, depletion of wildlife and other natural resource base, changes in the vegetation type, decline in forest resources, decline in soil conditions (soil moisture and nutrients),

increased health risks and the spread of infectious diseases, changing livelihood systems (Ishaya and Abaje, 2008). It can also be deduced that 4.8% of teachers are not concerned about climate change. This could be as a result of ignorance or negligence.

Table 2: Teachers response on climate change

Characteristics	Variables	Frequency (n = 188)	Percentage
Aware of climate change	***Yes***	104	55.3
	No	84	44.7
Concern about climate change	***Not concerned***	9	4.8
	Partially concerned	20	10.6
	Concerned	50	26.6
	Very concerned	109	58.0
Prevent climate change	***Government***	11	5.9
	People	6	3.1
	All	171	91
Can Govt. do anything?	***Yes***	100	53.2
	No	88	46.8

Causes of Climate Change

Table 3 showed the causes of climate change from the teachers' perspective. Deforestation has the highest percentage (99.5%). Cutting down forests faster than they are replaced (deforestation) is a major contributor to climate change. The implication of deforestation is that a lot of CO2 will be emitted to the atmosphere. This is corroborated by IPCC (2010) that 5.9 billion tonnes of CO_2 per year to be released into the air. Deforestation makes such a huge contribution to carbon emissions because trees absorb CO_2 as they grow. The more trees that are cut down, the fewer there will be left to absorb CO_2, leading to it building up in the atmosphere (IPCC, 2010). In addition, the agriculture and industry that replace the forests often cause an extra problem by producing carbon emissions of their own.

Table 3: Causes of climate change

Causes	Frequency (n = 188)	Percentage
Deforestation	187	99.5
Air pollution	174	92.6
Bush burning	161	85.6
Refuse disposal method	126	67.0
Industrialization	109	58.0
Poverty	153	81.4
Population	180	95.7
Mining operations	92	48.9

CONCLUSION AND RECOMMENDATIONS

Conclusion

Climate change affects not only human settlements and health but also, water resources, wetlands, industry, commerce, financial services, food security, land degradation, forestry and biodiversity.

Recommendations

- It is recommended that climate change awareness should be created on the students via their teachers and consequently, the whole populace. In this respect, efforts should be made to put in place integrated approaches for the adaptation and mitigation and one sustainable way to achieve this is through education and capacity building. To realize this, the curriculum of educational institutions has to be revised to accommodate the current issues of climate change. Such revision will ensure that people gain detailed knowledge and awareness of the danger associated with the disequilibrium in the natural arrangements and working of the environment.
- There is an urgent need for climate change issues to be infused into the curricula of schools right from the elementary to the university level in the country as a matter of urgency. This will ensure that the learners gain knowledge and understanding about climate change. Also the learners who are exposed to climate change would avoid acts capable of threatening the ozone layer.
- The Recommendations for a powerful and efficient climate change education in Nigeria can be summed up as follows:

- That climate change education shall be incorporated into subjects like agriculture, biology, chemistry, social studies, moral instruction, civics, physics etc in Nigeria to provide effective and efficient awareness of the dangers of climate change;

-That the incorporation of the climate change education into the these subjects should be premised on integrated approach;

That the teachers who will handle the issues of environment and climate change should be provided with professional development programmes to enhance their competence and disposition; and

-That Environment Protection Club should be set up in schools and the learners are encouraged to belong to the club.

REFERENCES

Fourchard, L. (2003). Urban Slums Reports: A Case of Ibadan Nigeria. IFRA. University ofIbadan Nigeria, Ibadan, Nigeria

NBS (2006). Nigerian population census results. Nigerian Bureau of Statistics. Available at: http://www.nigerianstat.gov.ng/nbsapps/Connections/Pop2006.pdf

Olorunfemi, F. (2010). Risk communication in climate change and adaptation: Policy issues and challenges for Nigeria. http://iopscience.iop.org/1755-1315/6/41/412036/pdf/ees9_6_412036.pdf

Ishaya, S.1 and Abaje, I. B (2008). Indigenous people‟s perception on climate change and adaptation strategies in Jema‟a local government area of Kaduna State, Nigeria. *Journal of Geography and Regional Planning Vol*. 1(8), pp. 138-143, November, 2008 Available online at http://www.academicjournals.org/JGRP ISSN 2070-1845

Khan, M. A. (2006). The role of teacher educators in environmental education. http://wgbis.ces.iisc.ernet.in/energy/lake2006/programme/programme/proceedings/Presentations/Lake 2006 - Presentations/30 Dec 2006/Sess http://www.un.org/womenwatch/feature/climate_change/d

Assessment of Weather and Climatic Parameters for Five Decades in Ibadan, Southwestern Nigeria

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ABSTRACT

Weather parameters of rainfall quantity, rainy days, minimum and maximum temperatures with humidity were assessed in Ibadan, south-western Nigeria. Daily records of these variables were taken on daily basis at the weather station in Forestry Research Institute of Nigeria over a period of fifty years (1965 to 2014). The fifty-year period was divided into five decades and the data generated were reduced to their means and subjected to both continuous statistics of bar chart and inferential statistics of standard deviation, Chi-square and their tests of significance. Results showed that rainfall pattern in Ibadan over the study period was irregular; also there was almost a steady decline in the number of rainy days from 1965 to 2014 but all rainfall parameter values were significant at 5% level of probability. On the basis of maximum temperature, the pattern was irregular because it followed a fluctuating movement over the fifty years. It was also observed that there was a steady rise in minimum temperature throughout but all temperature distribution values were also were significant at 5% level of probability. Comparing rainfall with relative humidity, there was a sharp decline in humidity figures and only the mean rainfall and mean number of rainy days values had significant distribution at 5% level of probability. The findings above tend to confirm climate change in Ibadan, the consequences were highlighted and different measures to combat the problem were recommended.

Keywords: Weather, climate, climate change, rainy days, humidity, temperature

INTRODUCTION

Forests have been shown to be a regulator of the environment by slowing down soil erosion, controlling and storing run-off water and regulating its release into rivers and lakes (Otegbeye and Onyeanusi, 2006). Weather refers to the conditions of atmosphere over a short period of time while climate refers to the "behaviour" of the atmosphere over a relatively long period of time; the difference between the two is a measure of time (NASA, 2015). The main elements of weather are temperature, pressure, wind, precipitation, cloud and humidity (GolearnGoegraphy, 2010).

Ibadan as the largest city in West Africa is located within rainforest lowland zone with a mean annual rainfall of 1180 mm and pan evaporation rate of 1327mm (Adebayo, *et al.,* 2004). Its geographical location is latitude 7^0, 26' N and longitude 3^0, 54'E (Odofin *et al.,* 2007). In the city of Ibadan, the months of June, July, August, September and October have nice average temperatures but on the average, temperatures are always high; the warmest month is February while the coolest month is August, September is the wettest month and December is the driest month (World Weather and Climate Information, 2015).

Climate Change refers to deviation from the normal climatic conditions of an area due to the land-atmosphere, land-ocean and ocean-atmosphere interactions in balance of gases in the atmosphere (Okali, 2007). Climate change is highly noticeable in Ibadan as evidenced by the unpredictability surrounding the August Dry spell that guides farmers in planting (Odofin *et al.,* 2007). Climate change and Global Warming effects manifest themselves as rising temperatures, irregular humidity and rainfall patterns, flooding, erosion of coast plains, rising sea levels, drought, desertification, threat to natural water resources and increase in erosion (Aluko, 2008). Flooding and extreme precipitation go hand-in-hand but are not the same thing, while climate change may directly alter precipitation, flooding is a consequence of heavy rainfall which has a human component (Roberts, 2012).

Ibadan began as a war camp in1829 and since 1960s has grown to become the nation's largest urban centre:the growth of Ibadan into metropolitan city brings luxuries and opportunities, real and imagined which are not found in rural areas; these attractions made the city to grow at a rate to become difficult to manage especially on public utilities while services are extended legally and illegally to unplanned new areas (MACOS Urban Management Consultancy, 2006).This paper compares fifty-year rainfall with rainy days, humidity, minimum and maximum temperatures in Ibadan, south-western Nigeria.

MATERIALS AND METHOD

This study was carried out at the Forestry Research Institute of Nigeria, Jericho-Ibadan at the agro meteorological station. Weather parameters of rainfall, minimum and maximum temperatures, humidity and rainy days were taken on daily basis over a period of fifty (50) years (1965-2014). Rainfall volume was determined through rain gauge in millimetres, daily temperatures from minimum and maximum thermometer and recorded in degrees Centigrade, humidity through hygrometer but documented in percentages while numbers of rainy days were determined from daily counts and recording of rainfall. The 50- year period of data collection was divided into five decades of 1965-1974, 1975-1984, 1985-1994, 1995-2004 and 2005-2014.

RESULTS AND DISCUSSION

Rainfall and Rainy days in Ibadan for Five Decades in Ibadan

Figure 1 showed rainfall pattern against rainfall volume and the number of rainy daysin the study area. Decade 1 (1965-1974) had lowest mean rainfall (104.58mm) but highest number of rainy days (8.54). The second decade (1975-1984) had the highest mean rainfall quantity (120.06mm) but the mean rainy days were third in ranking following descending order (7.78 days). Decade 4 (1995-2004) had the mean lowest but one rainfall quantity (107.92mm) and the lowest mean number of rainy days (6.99 days) but the mean rainfall and rainy days were significantly different at 5% level of probability. The findings in this study showed that rainfall in Ibadan for the fifty years has been irregular and it agrees with Aluko (2007) that climate change and Global Warming effects manifest themselves as irregular humidity and rainfall patterns.

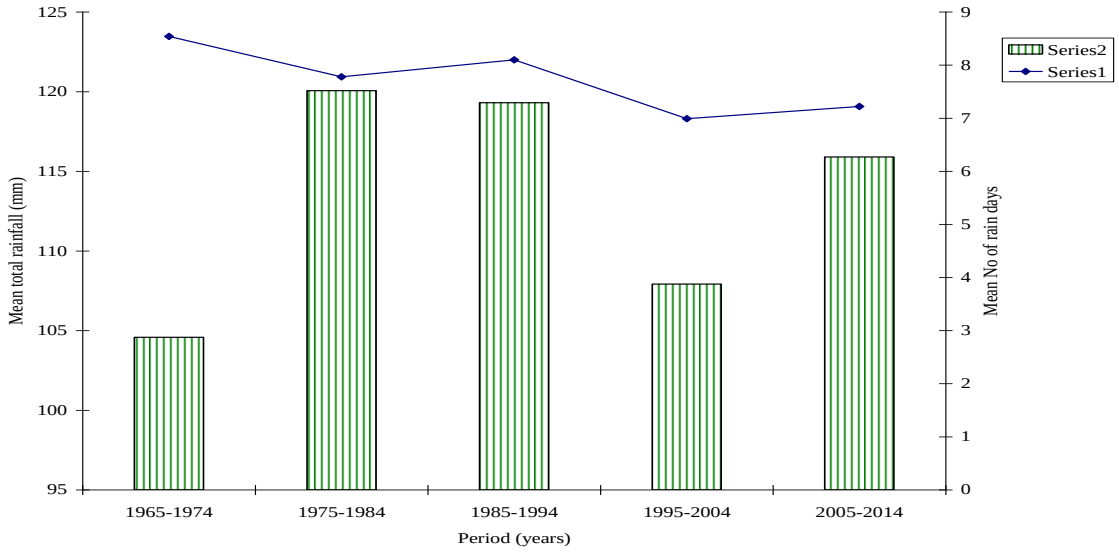


Figure 1: Rainfall and Rainy days in Ibadan for Five Decades in Ibadan

Mean Rainfall and Maximum Temperatures in Ibadan for Five Decades

Figure 2 compared mean rainfall for the five decades with the corresponding maximum temperatures. Decade 1 (1965-1974) had the lowest mean rainfall of 104.58mm but the second highest maximum temperature of 32.06 ^{0}C. Decade 4 had the last but one mean rainfall quantity of 107. 92 mm, but had the highest mean maximum temperature of 32.56 ^{0}C. The lowest mean maximum temperature belonged to Decade 3 but the rainfall quantity was ranked second highest during the study period. This pattern is also irregular for both mean rainfall and the mean maximum temperature but the mean rainfall and the mean maximum temperatures were significantly different at 5% level of probability. For the minimum temperatures, Decade 1 had the lowest mean minimum temperature of 21.51^{0}C, Decade 2 had 22.72^{0}C, Decade 3 had 23.32^{0}C, decade 4 had 23.71^{0}C and Decade 4 had 23.71^{0}C and Decade 5 had 24.36^{0}C.There was a steady increase in mean minimum temperatures over the five decades; also, the mean rainfall, mean maximum temperature and the mean minimum temperature had significant difference in distribution at 5% level of probability. This observation is an evidence of climate change and agrees with Okali, (2007) that Climate shows deviation from the normal climatic conditions of an area due to the land-atmosphere, land-ocean and ocean-atmosphere interactions in balance of gases in the atmosphere. This also conforms with Ogunjimi *et al.* (2008) that the earth has warmed by 0.6 ± 0.2 ^{0}Con the average since 1900 and that climatologically, record of

temperature and other parameters have shown considerable variation over the years. Also, Odofin *et al*. (2007) reported the unpredictability surrounding the arrival of August Dry Spell which guides farmers in their planting as an evidence of climate change.

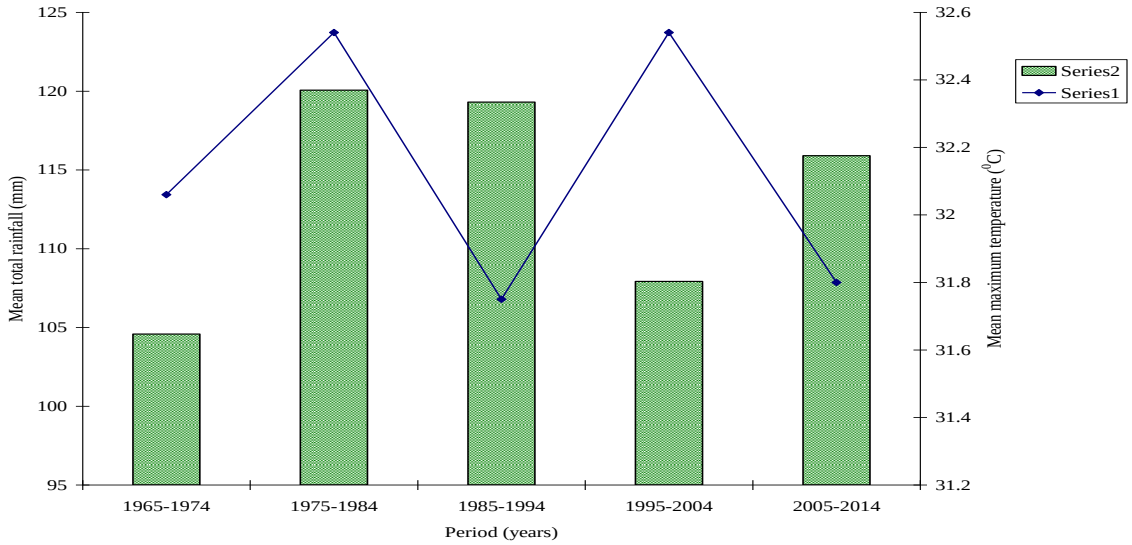


Figure 2: Mean Rainfall and Maximum Temperatures in Ibadan for Five Decades

Relationship between mean total rainfall (mm) and mean minimum temperature (^{o}C)

Figures 3 and 4 described mean rainfall and relative humidity for the study area in the study period. Usually the rainfall pattern was irregular but the mean relative humidity showed almost a sharp decline in quantity. Decade 1 had the lowest mean annual rainfall of 104.58mm but the highest mean relative humidity of 82.63%. Decade 2 had the highest mean rainfall of 120.06mm but the second highest relative humidity of 82.23%. Decade 3 with the second highest mean annual rainfall of 119.30mm had the third highest mean relative humidity of 79.94. Decade 4 with the last but onemean annual rainfall of107.92mm had the last but one mean relative humidity of 78.66%. Decade 5 with the third highest mean rainfall quantity of 115.90 mm had the lowest mean relative humidity. While the mean rainfall over the study years was irregular, the graph of mean relative humidity with the passage of time showed an inverse proportionality. Also, the mean annual rainfall and the mean relative humidity showed significant difference in distribution at 5 % level of probability. The effects of irregular rainfall and decreasing humidity manifest themselves as changes in animal migration pattern decrease in floristic richness and reduction in fruiting intensity (Ijeoma *et al*., 2008).

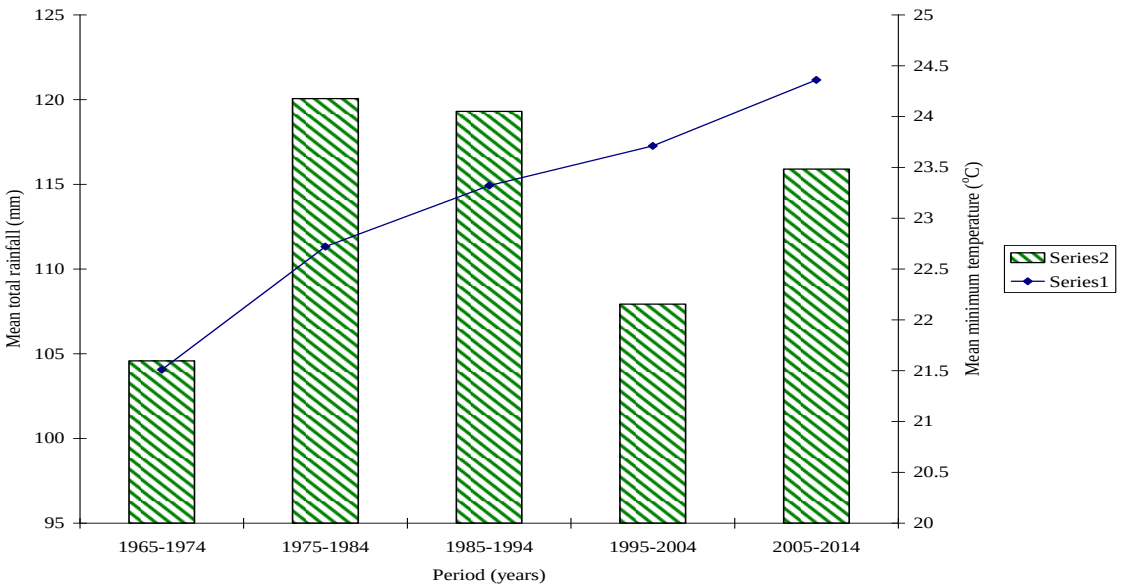


Fig 3: Relationship between mean total rainfall (mm) and mean minimum temperature (^{o}C)

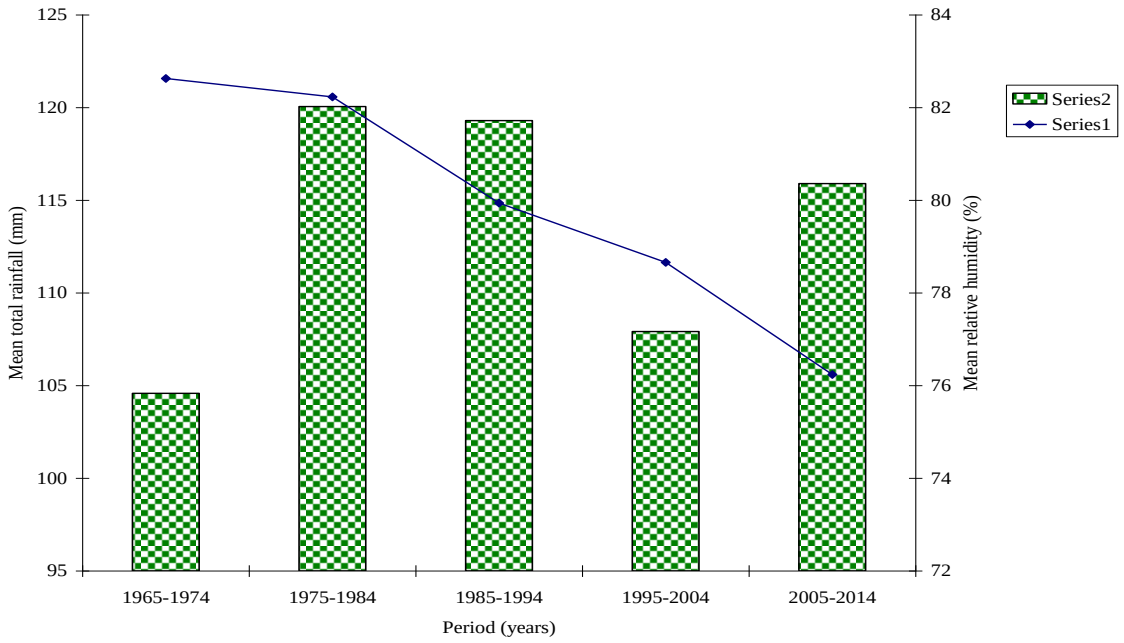


Fig 4: Relationship between mean total rainfall (mm) and mean relative humidity (%)

Statistical Indications of Parameters Assessed over the Years

Statistical tests of total rainfall in mm, mean rainfall, rainy days and mean rainy days were respectively 176331.20 , 567.76, 4625 and 38.63. The respective means were 35266.23, 123.55, 125, 5.1694 and 4.0942. The respective standard deviation values were 97.0579, 82.7433, 5.1694 and 4.0942. The Chi square value stood at 9.488 for all parameters and the distribution for all the parameters at 5 % level of probability was significant (Table1).

Table 1: Rainfall (mm) and Rainy Days for Five Decades in Ibadan

PERIOD	Total Rainfall(mm)	Mean	Rainy Days	Mean
1965 – 1974	122550.10	104.58	1025	8.54
1975 – 1984	12726.39	120.06	933	7.78
1985 – 1994	14196.20	119.3	964	8.10
1995 – 2004	12950.50	107.92	839	6.99
2005 – 2014	13908.00	115.9	864	7.22
SUM	176331.20	567.76	4625	38.63
MEAN	35266.23	133.55	925	7.73
SD	97.0579	82.7433	5.1694	4.0942
X^2-tab	9.488	9.488	9.488	9.488
Significance	15.729*	10.110*	9.880*	10.100*

*significantly different at 5% probability level

Statistical analysis of rainfall and maximum with minimum temperatures over the study years

Table 2 showed the statistical analysis of rainfall and maximum with minimum temperatures over the study years. Total rainfall in mm was 176331.20, total mean rainfall was 576.76, the total maximum temperature was 18794.30 ^{0}C; total maximum temperature was 18794.30, total mean maximum temperature was 160.69^{0}C. Total minimum temperature was 13508.30^{0}C while the total of means for minimum temperature was 115.62^{0}C. The grand mean values were rainfall (35366.33), mean rainfall (133.55), maximum temperature (3758.86), mean maximum temperature (160.69), minimum temperature (13508.30) and mean minimum temperature (23.12). The respective standard deviation values followed almost a steady decrease as: rainfall (97.0579), mean rainfall (82.7433), maximum temperature (100.3041), mean maximum temperature (21.014), minimum temperature (2701.66) and mean minimum temperature (23.12). The respective Chi square values stood at 9.488 and the respective significance values were rainfall (15.729*), mean rainfall (10.110*), maximum temperature (21.742*), mean maximum temperature (11.985*), minimum temperature (18.432*) and mean minimum temperature (9.917*). All values were significant at 5% level of probability indicating that climate is being manipulated in the form of unsteady maximum and steady rise in minimum temperature. This situation is borne out of ozone layer depletion (Halidu *et al*., 2009), deforestation generally degraded environment and pollution (Adegbola *et al*., 1998).

Table 2: Rainfall (mm) with Maximum and Minimum Temperatures for 5 Decades in Ibadan

Period	Rainfall (mm)	Mean (mm)	Max. Temp (^oC)	Mean (^oC)	Min. Temp (^oC)	Mean (^oC)
1965 – 1974	12550.06	104.58	3847.00	32.06	2581.00	21.51
1975 – 1984	12726.39	120.06	3449.00	32.54	2408.00	22.72
1985 – 1994	14196.20	119.30	3778.00	31.75	2775.00	23.32
1995 – 2004	12950.50	107.92	3904.30	32.54	2821.30	23.71
2005 – 2014	13908.00	115.90	3816.00	31.8	2923.00	24.36
SUM	176331.20	567.76	18794.30	160.69	13508.30	115.62
MEAN	35266.23	133.55	3758.86	32.14	2701.66	23.12
SD	97.0579	82.7433	100.3041	21.014	98.545	9.443
X^2-tab	9.488	9.488	9.488	9.488	9.488	9.488
Significance	15.729*	10.110*	21.742*	11.985*	18.432*	9.917*

*significantly different at 5% probability level

Statistical figures of rainfall and relative humidity assessment in the study area over the study period

Table 3 explained the statistical figures of rainfall and relative humidity assessment in the study area over the study period. Sum of rainfall was 176331.20mm while the sum of rainfall mean was 133.55mm. Total relative humidity was 46656.00 but total mean relative humidity was stood at 399.70%. Mean for total rainfall was 35266.23 while the grand mean for mean rainfall was 133.55mm. The mean for relative humidity was recorded as 9331.20 but its grand mean was 79.94%. The corresponding standard deviation figures followed a steady reduction and were distributed as rainfall (97.0579), mean rainfall (82.7433), relative humidity (72.331) and mean relative humidity (15.773). Tabulated Chi square value was 9.488 throughout while the tests of significance for rainfall was 15.729*, mean rainfall was 10.11*, relative humidity was 9.016^{ns}but mean relative humidity figure was 8.324^{ns}. Only rainfall and mean rainfall had significant difference in distribution over the study years at 5 % level of probability.

Table 3: Rainfall (mm) and Relative Humidity for 5 Decades in Ibadan

Period	Rainfall	Mean	R.H	Mean
1965 – 1974	12550.06	104.58	9916.00	82.63
1975 – 1984	12726.39	120.06	8716.00	82.23
1985 – 1994	14196.20	119.30	9513.00	79.94
1995 – 2004	12950.50	107.92	9439.00	78.66
2005 – 2014	13908.00	115.90	9072.00	76.24
SUM	176331.20	567.76	46656.00	399.70
MEAN	35266.23	133.55	9331.20	79.94
SD	97.0579	82.7433	72.331	15.773

X^2-tab	9.488	9.488	9.488	9.488
Significance	15.729*	10.11*	9.016^{ns}	8.324^{ns}

*significantly different and ns = not significantly different at 5% probability level

CONCLUSION AND RECOMMENDATION

Weather and climatic parameters in Ibadan is undergoing a shift in distribution towards irregular rainfall, decrease in the number of rainy days, non-steady maximum temperature pattern; increase in minimum temperature and decline in relative humidity over a period of five decades. This is evidence of climate change which disturbs biological cycles and leads to extinction of our valuable biodiversity. There is evidence that climate change due to ozone layer depletion is already affecting biodiversity and will continue to do so. The millennium ecosystem assessment ranks climate change among the main direct drivers affecting ecosystems. Consequences of climate change on the species components of biodiversity include:- change in destitute, increased extinction rates, change in reproduction timing and changes in the length of growing season for plants. Although ecosystem have adapted to changing conditions in the past, current changes are occurring at rates not seen historically. In general, the faster the climate changes, the greater the impact on biodiversity. Reduction in anthropogenic greenhouse emission can lessen this pressure, given the system more time to adapt.

In addition to mitigation, therefore, there is an urgent need to develop and implement climate change adaptation plans. Indeed, activities that lead to the degradation of the environment such as deforestation and overgrazing should be avoided. While there is, still more to understand about ozone layer destruction/climate change, enough is known about the range of impacts, the magnitude of risks and the potential for adoption to act now.

REFERENCES

Adebayo, O., Akinyemi, O. and Ojo, M.O.(2004). Cultivation, Uses and Utilization of Bitter-leaf *Vernonia amygdalina* Del in Ibadan,Oyo State, Nigeria. *Journal of Forestry Research and Management* 1 (1&2), December, 2005, 34-35.

Adegbola, P.O., Ashiru, M.O. and Alebiosu, B. (1998).Apiculture and Under-utilised Forest Resources. Paper Presented a Workshop on Agroforestry and Land Management Practices, Abeokuta, Ogun State. 10th November, 1998. 23pp

Aluko, A.P. (2008). Implication of Climate Change and Deforestation on Sustainable Development: Challenges to Nigeria. Paper Presented at Bisrod Furniture Company, Ijebu-ode, Ogun State, Nigeria on Behalf of Forestry Research Institute of Nigeria, Ibadan on 20th November, 2008. 22pp.

Coker, A.O., Awokola, A.S., Olomolaye, P.O. and Booth, C.A. (2007). Challenges of Urban Housing Quality and its Associations with Neighbourhood Environments: Insights and Experiences of Ibadan City, Nigeria Available on line at www.cieh.org/jehr/challenges...urban.com. Retrieved 5th June, 2015.

GolearnGeography, (2010). Elements of Weather and Climate . Available on line at www.golearngeo.wordpress.com/2010/08/29. Retrieved 4th June, 2015.

Halidu, S.K., Meduna, A.J., Mustafa, M.O., Likita, I.B. and Ogunjobi, J.A. (2009). Ozone Layer Depletion and its Effects on Biodiversity. In : Proceedings of Maiden annual Conference of Association of Women in Forestry and Environment (AWIFE). Adebola Adegeye (*ed*). Forestry Research Institute of Nigeria, Ibadan. 1st-5th November, 2009. 42-45pp.

Ijeoma, H.M. and Aiyeloja, A.A. (2008). Climate Change and Sustainable Tourism Management in Nigeria.In: *Proceedings of the* 32nd *Annual Conference of Forestry Association of Nigeria* (FAN), Popoola, L. (*ed*); Umuahia, Abia State, Nigeria. 20th-24th October, 2009.

MACOS Urban Management Consultancy(2006). Origin of Ibadan. Available online at www.macoscosultancy.com/Ibadan%2520met. Retrieved 5th June, 2015.

Mustafa, M.O., O.A. Ugbogu, O.D. Akinyemi., S.K. Halidu and O.O. Olasupo (2008). Acceptability of Phytomedicine in Ibadan and Environs. *Journal of Sustainable Environmental Management,*Vol.1, No. 1, 41-44.

NASA, 2015. What's the Difference between weather and climate? Available on-line at www.nasa.gov./....climate...weatherhtml. Retrieved 4th June, 2015

Odofin, B. T., Halidu, S. K. and Akinyemi, O. D. (2007). Implications of weather and climate on Sustainable Agriculture in Rainforest zone of Nigeria. In: *Proceedings of international conference of Nigerian Meteorological Society*, held at Federal University of Technology, Akure, Nigeria. 11th-15th November, 2007. 39-40pp.

Okali, D.U.U. (2007). Climate Change and Sustainable Development; Challenges to Nigeria. Paper presented at 38th Interdisciplinary Research Discourse, Post GraduateSchool, University of Ibadan on 28th November, 2007. 26pp

Otegbeye, G.O and Onyeanusi, A.E. (2006). Impact of Deforestation on Soil Erosion and on the Socio-economic life of Nigerians.

In Sustainable Environmental Management in Nigeria (eds) Ivbijaro, F.A, Akintola, F. and Okechuckwu, R. Mattivi Productions. Ibadan. 125 pp

Roberts, F. (2012). Five things to know about Flooding and Climate Change. The carbon brief; available on-line at www.weatherandclimate.org Retrieved 4th June, 2015.

World Weather and Climate Information (2015). Weather and Climate of Ibadan. Available on-line at www.weatherandclimate.com/average.... Retrieved 4th June, 2015.

Ogunjimi, A, Ayeloja, A.A., Meduna, A.J., Oyeleke, O.O. and Unaeze H.C. (2008): Potential Impacts of Climate change on Biodiversity and Socio-cultural Values of National Parks. In: *Proceedings of 32nd Annual Conference of Forestry Association of Nigeria* (FAN), Popoola, L (*ed*) Umuahia, Abia State. 20th – 24th October, 2008. 86-96pp.

Biofuel Potentials of Some Forest Plant Seed Oils in Abeokuta, Nigeria

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ABSTRACT

The potential of some forest plant seed oils for biofuel was investigated. The seed oils of Adansonia digitata (Linn.) Vitellaria paradoxa, (Gaetner.f.) Hepper and Cocos nucifera (Linn.) were extracted and converted to biofuel using transesterification with potassium hydroxide as catalyst and their usefulness as source of biofuel were determined. Adansonia digitata, was not further processed into biofuel because the oil yield was low (14%). The feedstocks were sourced from Abeokuta and biofuels were characterized for key fuel properties: iodine value, flash point, cetane number and specific gravity using standard procedures. Gross margin analysis was carried out to assess the economic implication of the biofuel produced, using International market price (USA average). The results showed 90% biofuel yield from V. paradoxa, C. nucifera with associated glycerine as a useful by product. Measured properties of the biofuel produced, revealed the mean specific gravity (g/cm^3) as 0.858, for V. paradoxa and 0.856 for C. nucifera. The mean iodine values were 71.1 for V. paradoxa and 80.2 for C. nucifera. . The mean flash point was 195^oC for V. paradoxa and 161^oC for C. nucifera. . The cetane numbers were 36.5, for V. paradoxa and 51 for C. nucifera. The gross margin analysis of the biofuel produced showed the margins to be ₦1.665, ₦4.165, per litre. Statistically, at $P< 0.05$, the result showed that there is no significant difference in all the properties tested among the biofuel produced. The biofuel produced met the requirements of ASTM D6751-02. It was concluded that these forest plant seed oils investigated could serve as biofuel after conversion and thus recommended that plantations of these trees be established to make feedstocks available and make biofuel production economical and sustainable.

Keywords: Biofuel, Forest plant seed, Gross-margin, extraction

INTRODUCTION

Biofuels are any source of fuel or energy that is produced from organic matter, or combustible oils produced by plants or animals.Rise in global demand is making alternative fuels more attractive. With rising worldwide demand for fossil, the need for alternative biofuel oil sources to help nations achieve greater energy independence has become necessary. Nigeria need a more reliable renewable energy supply sources such as biofuel to compliment our fossil fuel. (Georgia Biofuel Directory, 2003).

Biofuel is a product from renewable resources that is widely used in Europe and the United States. It is a highly refined engineered organic fuel that can be manufactured using virtually any oil from plants, animal fats, or even waste grease. It can be blended with petroleum fuel at any level and used in most heating equipment and diesel engines without modification. (Wilsons, 2006). Biofuel is easy to use because it requires no change of existing technology. Oil fired furnaces and diesel engines are already equipped to burn this fuel. It has a higher cetane number than petroleum based diesel, leading to more complete combustion and less tailpipe smoke in diesel engines. Increased lubrication of the fuel lessens wear on engines. It also acts as a biological solvent which dislodges carbon deposits and cleans the vehicle's fuel system and injectors. This solvent action also acts to reduce the build up of petroleum sludge in oil tanks and keep burner nozzles clean. The cleaner burn decreases soot build-up enhancing performance and reducing maintenance (Wilsons, 2006).

Biofuel has a positive effect on the environment because it significantly reduces emissions contributing to global warming, smog and acid rain when it is used at 100% or even at a blend of B20 (20% biodiesell and 80% conventional diesel/fuel oil). The environmental facts about biofuel are numerous and which are; the overall ozone (smog) forming potential of the speciated hydrocarbon exhaust emissions from biofuel is 50% less; the exhaust emissions of carbon monoxide and particulate matter from biofuel are 50% lower;; the exhaust emissions of sulfur oxides and sulfates from biofuel are completely eliminates; the exhaust emissions of unburned hydrocarbons are 95% lower than fossil fuel (Wilsons, 2006). The combustion of fossil fuels has increased the concentration of CO_2 in the earth's surface atmosphere which has led to increased global warming. Petroleum Diesel and gasoline also consists of blends of hydrocarbon chains; many of which are toxic, volatile compounds and are responsible for the health hazards and pollution associated with combustion of carbon monoxide, nitrogen oxide, sulfur oxides and particulates.

Biofuel if pure, or 100%, is referred to as B100 or "neat" biofuel (NBB, 2008). The use of biofuel has a lot of health, and environmental benefits. Biofuel is non-toxic, degrades about four times faster than petroleum diesel (NBB, 2008). Biofuel is safer for people to breathe, it helps to preserve and protect natural resources. The ozone forming potential of hydrocarbon exhaust emissions, of carbon monoxide from biofuel are both 50% lower compared to petroleum diesel. The exhaust emissions of particulate matter from biofuel are 3% lower. The exhaust emissions of sulfur oxides and sulfates from biofuel are completely eliminated (NBB, 2008). Biofuel is a non petroleum fuel made from organic materials or otherwise known as renewable resources. It can be blended with petroleum in any percentage to run diesel engine and use in any diesel engine without alterations or conversions. The non-toxic substance is registered as a fuel and fuel additive with the Environmental Protection Agency. Studies have shown that burning biofuel significantly reduced the impacts of global warming, smog and asthma. It produces at least 70% less greenhouse gases than gasoline and is 85% biodegradable in water in less than a month. It is not only good for planet, but for diesel car engines as well. The use of biofuel can actually extend the life of a diesel engine because it is more lubricating (Kristin, 2004).

Renewable fuel unlike the fossil fuel improves the environment because the plants grown to make these fuels take greenhouse gases such as carbon dioxide out of the atmosphere and fix it in their roots, stems and leaves. Much of this carbon dioxide gets sequestered in the soil, reducing the overall level of carbon dioxide in the atmosphere. Discovering useful forest plants seed oils that can serve as feed stock for the production of biofuel will go a long way towards, reducing the nation's total dependence on fossil fuel, reduce competition on edible food that serve as feedstock presently, and more importantly help to improve the environment. Forests contain many useful plants and animals of subsistence and commercial values for sustenance of rural economies. According to Jonah *et.al*, 2013 the consumption and trade in these goods and services are not properly documented and were thus tagged "minor forest products". This grossly underscores the enormous socio-economic and cultural significance of these resources and hence the failure of politicians and policy makers to take their sustainability very seriously. (Jimoh *et al*., 2001).

In order to widen the scope of feedstock that could be used as a source of biofuel production and for maximum utilization of forest resources in forestry and source for fuel that would be environmentally friendly, the oils from the seeds of *Adansonia digitata* (Linn.*)*, *Vitellaria paradoxa*, *Cocos nucifera*, were chosen to evaluate their potentials as biofuel source.

METHODOLOGY

Source of Data

The data for this study was obtained in the laboratory Department of Forestry and Wildlife Management Laboratory, University of Agriculture, Abeokuta, Nigeria.

Method of Data Collection

Adansonia digitata, *Vitellaria paradoxa* kernel and *Cocos nucifera* fruit were procured during their seasons from the forest and homestead. The trees were randomly selected, their seeds were gathered, and their oils were extracted and converted to biofuel in the 3.2.4

Methods of Seed/ Kernel/Fruit Oil Extraction

The seeds that were sampled were based on the fact that they were from forest trees and they have oil. They were prepared and the oil was extracted by soxhlet extraction and manual press method as state below;

Raw Material Preparation

Oilseeds and nuts of *Adansonia digitata*, and *Vitellaria paradoxa* kernel, were properly dried, and cleaned to remove sand, dust, leaves and other contaminants. Fruits of *Cocos nucifera* were harvested when fully ripe, cleaned and handled carefully to reduce bruising and splitting. The fruits were dehisced and split manually. All raw materials were sorted to remove stones and mouldy nuts. This was stored in weatherproof, ventilated rooms which were protected against birds, insects and rodents. *Adansonia digitata*, *kernel* were milled with hammer mill before extraction to reduce the surface area of the seeds in order to increase the oil yield. The more finely divided the solid is, the faster the reaction happens. A powdered solid will *normally* produce a faster reaction than if the same mass is present as a single lump. The powdered solid has a greater surface area than the single lump. (Jim, 2002).

Procedure I: Soxhlet Extraction

Various solvents have been used to extract oil from the seeds of oil plants. These include petroleum ether; diethyl ether; chloroform; methanol; n-hexane (Kubo *et al*, 1986; Adetogun *et al*, 2003). This could either be by cold solvent extraction which involves shaking of milled seeds with the organic solvents or using soxhlet extractors placed on steam bath or electric furnace. One hundred grammes of milled sample of *Adansonia digitata*, was weighed on top loading weighing balance. The weighed samples were extracted separately in the soxhlet extractor using petroleum spirit (b. p. 60-80^{0}C) as the solvent. The extractor was placed on a steam bath for 24 hours to ensure complete extraction. The petroleum spirit-oil mixture was collected in the round bottom flask of the extractor. The procedure was repeated three times for each sample. Evaporation in vacuo: In order to separate the oil from the solvent, the mixture was evaporated in vacuo using a rotary evaporator. The mixture of the petroleum spirit and the oily liquid in the 500ml round bottom flask was connected to a rotary evaporator. The temperature regulator was at 80^{0}C being the boiling point of petroleum spirit. The rotavapor was set at 7rpm. The solvent was collected in the 100ml round bottom flask while the oily extract left in the 500ml round bottom flask was measured with a measuring cylinder and stored in the storage bottle.

Procedure II: Manual Press

Oil can be extracted by using manual pressing and expeller from the softer oilseeds and nuts, such as groundnuts and shea nuts, whereas harder, more fibrous materials such as copra and sunflower seed can be processed using ghani method. (Salvador, 2007) The *Vitellaria paradoxa* nuts, *and Cocos nucifera* fruit, seed oil were extracted using manual press in which 20kg of pulped/ground/fried samples were loaded separately into a manual press to squeeze out the oil. A long pivoted lever moves a piston backwards and forwards inside the cylindrical cage, constructed from metal bars spaced to allow the passage of oil. At one end of the piston's stroke, it opens an entry port from the seed hopper so that seed enters the press cage. When the piston is moved forward, the entry port is closed and the oilseed is compressed in the cage. As a result, oil was expelled from the oilseed and emerges through the gaps in the cage. Compressed seed was pushed out through a circular gap at the end of the cage. The amount of oil extracted in each extraction was determined using the formula below:

$$\% \text{ oil extracted} = \frac{\text{volume collected}}{\text{Wt of initial material}} \times \frac{100}{1}$$

Procedure III: Biodiesel Preparation

Transesterification

The method of converting oil to biodiesel (a form of biofuel) is called Transesterification. During transesterification, a basic catalyst breaks the fatty acids from the glyerine one by one. If a methanol contacts a fatty acid, they will bond and form ester which is the biodiesel. The hydroxyl group from the catalyst stabilizes the glycerine. The procedure of Addison and Hiraga (2007) was adopted in the conversion of the oil extracted into biofuel because it is a batch process which could be used at subsistence level. Two hundred (200ml) of methanol was measured into the High Density Poly ethylene (HDPE) container via the funnel. 4.9 grammes of lye (KOH) was carefully added to the HDPE container via the second funnel. The bung and the screw were replaced on the cap tightly. The container was shaken (swirled round) for about ten minutes to dissolve the lye in the methanol, forming potassium methoxide. The oil was pre-heated to 55^{0}C and poured into the blender. With the blender still switched off, the prepared methoxide was carefully poured from the HDPE container into the oil. The blender was tightly secured and switched on. The lowest speed was used to make the reaction thorough and was blended for twenty-five (25) minutes. As soon as the process was completed, the mixture was poured from the blender into the polyethylene terephthalate (PET) settling bottle and the lid was screwed on tightly. It was allowed to settle for twenty-four (24) hours. Darker-coloured glycerine by-product was collected in a distinct layer at the bottom of the bottle, with a clear line of separation from the light to dark yellow clear liquid above, which is the biofuel. The top layer was carefully decanted into a

clean PET bottle, taking care not to get any of the glycerine layer mixed up with it. The biofuel was later refined or purified by washing with clean water to remove excess alcohol, traces of soap, residual catalyst and other particles through thin layer chromatography, which proceeds rapidly at room temperature under 10 kbar pressure, giving quantitative yields. Drying was finally done to improve its shelf life and to obtain pure biofuel.

Measurement of Properties of the Biofuel

This was carried out on the biofuel produced from the oils of *Vitellaria paradoxa,* and *Cocos nucifera.* The aim is to establish the quality of the biodiesel, whether it could actually serve as alternative to fossil fuel.

Procedure IV: Determination of Specific Gravity of Biofuel

ASTM D6751-02 was used to determine the specific gravity of the biofuel producedThis was determined by weighing a given measure of oil sample compared with the mass of an equal volume of water. The mass of an empty graduated cylinder was determined as X_1g by weighing on graduated scale. Thegraduated cylinder was filled with the oil to the 50ml level, the oil's volume was determined in X_2cu.cm. Themass of the oil and graduated cylinder was determined on the graduated scale in X_3g. The mass of the oil wasdetermined as (X_3-X_1) grammes. The specific gravity of the oil at room temperature was determined by the formula:

$$\text{Specific gravity} = \frac{X_3 - X_1 \text{ grammes}}{X_2 \text{ cu.cm}}$$

Procedure V: Determination of the Iodine Value of the Biofuel

The iodine value was determined using ASTM D5768 - 02(2006) standard. 0.2 g of oil was weighed out into a clean dry iodine flask of 500ml capacity. It was then dissolved in about 10ml of carbon tetrachloride.25ml of hanus solution was added to it from a burette. The flask was gently rotated to mix the contents thoroughly. The tip of the flask was moistened with potassium iodide. The flask was kept in the dark for half an hour. Then 20ml of 10% potassium iodide solution was added to the mixture diluted by adding 200ml of water. The mixture was titrated with standard thiosulphate solution using starch as indicator.

Procedure VI: Determination of Flash Point of Biofuel

Procedure: ISO/CD 13736 standard was used to determine the flash point of the biofuel produced. 20g of the oil was weighed and placed in the test cup of an Abel apparatus and heated to give a constant temperature increase with continuous stirring. A small test flame was directed through an opening in the test cup cover at regular temperature intervals with simultaneous interruption of stirring. The lowest temperature at which application of the test flame causes the vapour of test portion to ignite and propagate over the surface of the liquid was recorded as the flash point at the ambient barometric pressure. The temperature was corrected to standard atmospheric pressure using this equation.

The corrected flash point, *T*c, was calculated using the following equation.

$Tc = To + 0, 25\ (101, 3 - P)$ Where:

*T*o = the observed flash point, expressed in degrees Celsius;

P = barometric pressure at 0°C, expressed in kilopascals

Procedure V11: Determination of Cetane Number of Biofuel

Procedure: ASTM D-613 (ISO 5165) standard was used to measure cetane number. It was measured by burning the fuel in a special hard-to-find, diesel engine called a Cooperative Fuel Research (CFR) engine, under standard test conditions. The CFR engine's pressure was then increased within the cylinder of the engine until the time between fuel injection and ignition is 2.407ms, the resulting cetane number was then calculated by determining which mixture of cetane and isocetane (2, 2, 4, 4, 6, 8, 8-heptamethylnonane) resulted in the same ignition delay.

Data Analysis

The data collected was analysed using Gross Margin Analysis and Analysis of Variance. Gross margin analysis was estimated, using the data collected. This is because majority of the inputs are variable costs. The costs, quantity of various inputs and price of feedstock used for each of the biofuel produced were used. Gross margin analysis was obtained by deducting the total variable costs from the total revenue. The cost of production was determined and compared with International markets price for biofuel in America and Canada, U. S. A. average to justify the economics of producing the products.

GM = TR - TVC…… (1)

Where:

GM = Gross margin

TR = Total Revenue derived from a litre of biofuel production (naira)

TVC = Total variable costs of producing biofuel per litre (naira)

Analysis of Variance (ANOVA)

This is basically an arithmetic method for breaking down the total variation of the collected data into components representing the sources of variation recognized in the experiment. (Akindele, 2004) Analysis of variance (ANOVA) is used to test hypotheses about differences between two or more means.

RESULTS

Table 1: Oil Yield from the Various Seeds in Percentage (%)

Seeds	Percent Yield
Adansonia digitata	14
Vitellaria paradoxa nuts	39.5
Cocos nucifera fruit,	34

Table 2: Biofuel Yield from the Various Feedstocks (Millimeter/litre)

Biofuel Feedstock	Biofuel Yield (mm/litre)	Glycerine Yield (mm/litre)
Vitellaria paradoxa oil	900	50
Cocos nucifera fruit oil,	900	70

NB: Oil yield was determined by the use of calibrated beaker, which showed the quantity of biofuel produced and other products.

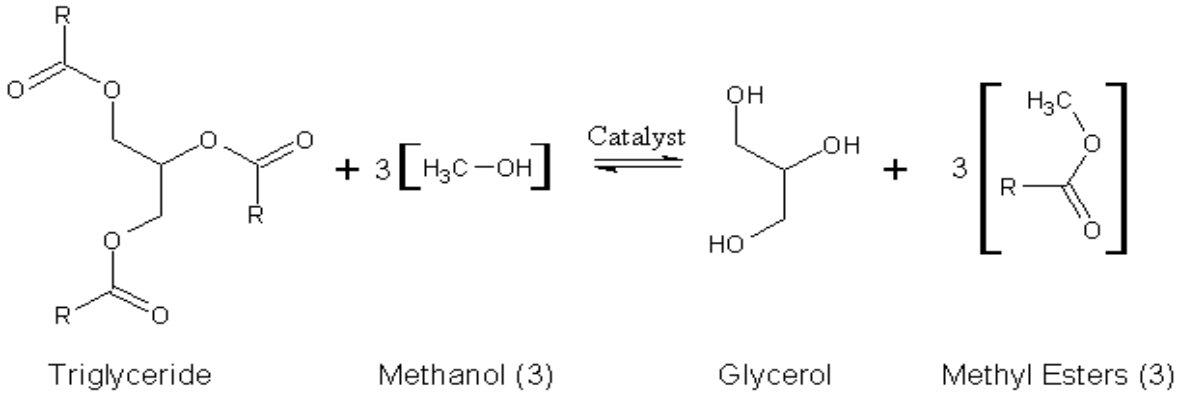


Fig. 1: Skeletal Reaction Pathway for Transesterification Process Ma & Hanna, 199

Table 3: Flash point (^{0}C) of the different biofuel produced

Biofuel	First trial	Second trial	Third trial	Mean
Vitellaria paradoxa	195	194	196	195
Cocos nucifera	161	160	162	161

Table 4: Variation between the Flash Point (^{0}C) of the Different Biofuel Produced

Biofuel	Mean ± Se	Sample variance	P- value
Vitellaria paradoxa	195 ± 1.0	2.0	$p< 0.05$
Cocos nucifera	161 ± 1.0	2.0	

F critical 6.59

Table 5: Specific gravity of the different biofuel produced

Biofuel	First trial	Second trial	Third trial	Mean
Vitellaria paradoxa	0.858	0.857	0.859	0.858
Cocos nucifera	0.856	0.857	0.855	0.856

Table 6: Variation between the Specific Gravity of the Different Biofuel Produced

Biodiesel	Mean ± Se	Sample variance	P- value
Vitellaria paradoxa	0.858 ± 0.001	$2x10^{-6}$	$p< 0.05$
Cocos nucifera	0.856 ± 0.001	$2x10^{-6}$	

Table 7: Cetane number of the different biofuel produced

Biofuel	First trial	Second trial	Third trial	Mean
Vitellaria paradoxa	35	37	36	36
Cocos nucifera	48	52	50	50

Table 8: Variation between the Cetane Number of the Different Biofuel Produced

Biofuel	Mean ± Se	Sample variance	P- value
Vitellaria paradoxa	36.5 ± 0.5	0,5	$p< 0.05$
Cocos nucifera	51.0 ± 0.5	2.0	

Fcritical 6.59

Table 9: Iodine value of different biofuel produced (g)

Biofuel	First trial	Second trial	Third trial	Mean
Vitellaria paradoxa	71.1	71.2	71.0	71.1
Cocos nucifera	80.2	80.3	80.1	80.2

Table 10: Variation between the Iodine Values of the Different Biofuel Produced

Biofuel	Mean ± Se	Sample variance	P- value
Vitellaria paradoxa	71.1 ± 0.1	0,02	$p< 0.05$
Cocos nucifera	80.2 ± 0.1	0.02	

Fcritical 6.59

Table 11: Fuel – Related Properties of the Different Plant Seed Oils Used

Oil	Iodine value (g)	Cetane number	Flash point (^{o}C)
Adansonia digitata oil	85.6	37.1	260
Vitellaria paradoxa oil	40.0	33.6	180
Cocos nucifera oil	60.0	36.0	150
Fossil fuel values range	20.5-38.5	35-55	55-60

Table 12: Gross Margin Analysis of the Different Biofuels Produced

Total variable cost	*V. paradoxa*		*C. nucifera*	
	Amount (₦)	% Total	Amount (₦)	% Total
Feedstock	500	73.43	490	73.13
Lye (KOH)	20.88	3.07	20.88	3.11
Methanol	160	23.50	160	23.85
Total	680.88		670.88	
Gross margin/gallon	6.66		16.66	
Gross margin/litre	1.665		4.165	

Revenue was derived using international market price for biofuel

(U.S.A. Average $3.0857/gallon ≈ N687.54k @ ₦222.82k/$1.00).

Table 13: International Comparism of Gross Margin Analysis of the Different Biofuels Produced

Total variable cost	*V. paradoxa*		*C. nucifera*	
	Amount ($)	% Total	Amount ($)	% Total
Feedstock	6.00	67.04	5.70	65.90
Lye (KOH)	0.55	6.15	0.55	6.15
Methanol	2.40	26.82	2.40	26.82
Total	8.95		8.65	
Gross margin/gallon	5.86		5.56	
Gross margin/litre	1.465		1.390	

Revenue was derived using international market price for biofuel (U.S.A. Average $3.0857/gallon.

Table 14: Sensitivity Analysis using Nigeria inflation rate of 13% to prepare Gross Margin Analysis of the Different Biofuels Produced

Total variable cost	*V. paradoxa*		*C. nucifera*	
	Amount (₦)	% Total	Amount (₦)	% Total
Feedstock	565	73.43	555	73.13
Lye (KOH)	23.60	3.07	23.60	3.11
Methanol	180.80	23.50	180.80	23.85
Total	769.40		759.40	
Gross margin/gallon	(81.86)		(71.86)	
Gross margin/litre	(20.47)		(17.95)	

Revenue was derived using international market price for biofuel (U.S.A. Average $3.0857/gallon

Table 15: Sensitivity Analysis using Proposed Nigeria Inflation rate of 15% to Prepare Gross Margin Analysis of the Different Biofuels Produced

Total variable cost	*V. paradoxa*		*C. nucifera*	
	Amount (₦)	% Total	Amount (₦)	% Total
Feedstock	575	65.64	563.50	73.13
Lye (KOH)	24.1	2.74	24.01	3.11
Methanol	184	21.01	184	23.85
Total	783.01		771.51	
Gross margin/gallon	(94.57)		(83.97)	
Gross margin/litre	(23.87)		(20.99)	

Revenue was derived using international market price for biofuel (U.S.A. Average $3.0857/gallon.

DISCUSSION

The results from the study revealed that percentage crude oil yield from the seeds of *Adansonia digitata* was very low, (14%). Further processing into biofuel was not done because it is not economical. Sidibe and Williams (2002) reported that the oil extracted from the seed of *Adansonia digitata* could be used for inflamed gums and to ease diseased teeth. It has a high content of vitamins A, D, E and F. It is also an excellent ingredient in formulations for eczema and psoriasis. It is used in small percentages in creams, lotions, body butters and other skin care formulations. (Natural Sourcing, LLC, 2009). The percentage crude oil yield from *Vitellaria paradoxa* nuts and *Cocos nucifera* fruit,were 39.5%, and 34%, respectively. The recovery rate of biofuel from the oils of *Vitellaria paradoxa*, and *Cocos nucifera*, after conversion were 90% and 92% respectively, with associated production of a useful by product glycerine of 0.5%, and 0.7%. This is also in line with Foidl *et al*., 1996, when *Jathropha curcas* seed oil was used as feedstock for biofuel and 92% of the theoretical yield was realized. The glycerine yield was also noteworthy as it could be used extensively throughout the pharmaceutical and cosmetics industries. Glycerine could be used as degreaser, it is a source of methanol, and it serves as floor cleaner, compost and emulsion breaker. Gradon, (2009) and Western Australia, 2006 laid particular emphasis on sourcing glycerine

from non-animal feedstocks saying it commands significantly higher prices than that sourced from tallow or other animal sources because of its quality.

The characteristics of the different biofuel feedstock revealed their quality to serve as alternative to conventional diesel. This depends on the fatty acid chains of the different feedstocks used for the transesterification process. The mean iodine value (g) of biofuel produced from the oil of *Vitellaria paradoxa* and *Cocos nucifera*, were 71.1 and 80.2. The values were high for both of them and showed the degree of unsaturation of the oil, which means that they are polyunsaturated; and they have iodine value classified under non- drying oil which made them suitable to run engine. The mean flash point or ignition point of the different biofuels was 195^{o}C and 161^{o}C; this is described as the lowest temperature at which a combustible liquid can be made to ignite in air. According to NNB, (2008), the flash point of conventional diesel is around 125^{o}F (52^{o}C). The biofuel produced has higher flash points and therefore biofuel and its blends at B_{20}, B_{10}, and B_5 are safer to store, handle and use than conventional fuel. (NBB, 2008). The cetane numbers were 36.5 and 51.0. This is a measure of oils combustibility under compression. The cetane number of conventional diesel is between 35 and 55. (NBB, 2008). The biofuel produced have their cetane number within this range and so could run even high speed passenger car diesel engines. The specific gravity was 0.858 and 0.856. This indicates that they can perform the function of conventional diesel since these values were within the range of conventional diesel density. The fuel related properties and iodine values of the different feedstock in their crude state showed that even in their natural state, the oils have inherent potential to function as biofuel. This is in line with Barminas *et al*., 2001, who worked on *Cyperus esculentus* (tigernuts) oil and discovered that it has inherent potential to function as biofuel. Foidly, *et al*., (1996) also worked on *Jathropha curcas* L. as a source for biofuel production in Nicaragua and showed that in its natural state it has inherent potentials to serve as biofuel. The economic viability of biofuel production of these oils revealed a very narrow margin for the different feedstocks. The margins were ₦1.665 and ₦4.165 per litre for *Vitellaria paradoxa and Cocos nucifera* respectively. The cost of production of this fuel is undoubtedly high even at International level when compared with conventional diesel because of the price of the feedstocks, but the "hidden" cost of health, the environment and agriculture for a more realistic look at conventional diesel's cost should not be forgotten. The sale of glycerine which is a byproduct from biofuel production is an important revenue stream to offset the cost. Also, if the feedstock is sourced from Non-timber forest products (NTFPs), the cost of production will be reduced drastically. Many of the NTFPs have been abandoned in past years because of major focus on Timber; most of these seeds have inherent potentials in them to solve the problem of mankind. The sensitivity analysis which revealed that the fluctuating inflation rate would affect the cost of production of biofuel, which in turn would affect the selling price and make it to be on the high side or otherwise. Though it worth's consideration, especially because of the competition with edible oils, but the health benefit that is associated with the use of biofuel should not be underrated and moreso, the depletion of fossil fuel which is imminent. The use of NTFPs which are considered as wastes would be appropriate.

One of the measures that can be taken to correct overall dependence on fossil fuels is to explore alternative fuels, in which biofuel is one. Biofuels are viable options, although they may not be the end solution. They can be locally produced, using local resources and providing all the environmental, health, agricultural and economic benefits explored earlier. Moving in this direction with the support of the communities and government would add markedly to a reduction in the dependence on fossil fuel. Biofuel which is a viable option to dependence on fossil fuels is most applicable in the transportation sector and could be used in other energy creating industries such as heating and electricity. Our national security will be re-stabilized when we as a nation take necessary steps to make changes in our lifestyles. Biofuel could be a part of that change. Individuals, businesses, and governmental entities should begin to see benefits of using biofuel.

Forest plants seed should not be seen as ordinary or waste, because lie therein may be resources that could change the orientation of a whole nation. Forest plants seed oil should be extracted and tested to check the hidden potentials in them, so as to solve human health and environmental problems. More feedstocks for biofuel that are forest based should be discovered to lessen the competition on the oils that are being consumed as foods. Government should see biofuel as a way out of many health, environment and agricultural problems and must look for a way of manufacturing it. People should be enlightened about health and environmental benefits of biofuel, so that they will not see it as a threat to their survival because of its price.

REFERENCES

Adetogun, A.C.: Aina, O. M.: and Ogunsanwo, Y. K., 2003. Evaluation of cashew shell liquid (CNSL) as wood preservative using crushing strength. *J. ASSET Series A.* 3(4): 55-61.

Addison, K.and Hiraga,M.2007.Journey to forever http://journeytoforever.org/.oldid005691

Akindele, S. O. 2004. Basic experimental designs in agricultural research. Royal Bird Ventures, Lagos. 190p.

Barminas, J.T.; Maina, H.M.; Tahir, S.; Kubmarawa, D. and Tsware, K. 2001. A preliminary investigation into biofuel characteristics of tigernut (Cyperus esculentus) oil. *Bioresource Technology* 79, 87-89

Biodiesel Market Prospectus *Ender Management Team, October,* 2005. *A*lternative Fuels Data Center. Biodiesel Fuel Market. www.enderllc.com/oldid. January, 2009

Foidly, N.; Foidly, G.; Sanchez, M.; Mittelbach, M. and Hackel, S. 1996. *Jatropha curcus* L. as a source for the production of biofuel in Nicaragua. *Bioresource Technology* 58, 77-82.

Gaydou, A.M.; Menet, L.; Ravelojaona, G. and Geneste, P. 1982. Vegetable energy sources in Madagascar: ethyl alcohol and oil seeds (French). Oleagineux 37(3):135-141.

Georgia Biofuel Directory, 2013: A directory of Georgia industries that use biofuels. May 2003. Funded by the Georgia Forestry Commission, The U.S. Department of Energy, the Georgia Environmental Partnership, and The University of Georgia.

Jonah, I J, Marcus, S. N, Ilori, I. A. 2013: Economics of Non-timber Forest Products (ntfps) in Oyo-state, Nigeria. *Iosr Journal of humanities and social science (Iosr-Jhss) Volume 18, issue 4 (Nov. - Dec. 2013), pp 01-18 e-ISSN: 2279-0837, p-ISSN: 2279-0845. Www.iosrjournals.org* www.iosrjournals.org.

Jim, C. 2002. The effect of surface area on reaction rates. Modified October 2013. http://www.chemguide.co.uk/physical/basicrates/surfacearea.html

Krinstin, B, 2004. Women pioneer biofuel to save mother earth. http://www.womennews.org/story/environment/041121/women-pioneer-biofuel-save- mother-earth. 20th June, 2008.

Kubo, I.K.: Sakae and Masamitsu, O. 1986. Molluscicides from the cashew Anacardium occidentale and their large scale isolation *J. Agric. Chem.* 34, 970-973.

National Biodiesel Board,2008. Biodiesel emissions. http://www.biodiesel.org. /doid4231. 3rd February, 2009.

Natural Sourcing, L LC. 2009. From Nature with love Baobab oil (*Adansonia digitata* FNWL.htm.http://www.fromnaturewithlove.com/…product.asp?...oilbaobab-united states. 24th March, 2009.

Romanski, J.; Nowak, P.; Kosinski, K.; Jurczak, J. 2012). "High-pressure transesterification of sterically hindered esters".*Tetrahedron lett.* **53** (39): 5287–5289.

Salvado, G. 2007. Practical answers, technical information on line; Oil extraction http://practicalaction.org/id=187 4th January 2008.

Sidibe, M. and Williams, J. T. 2002. BAOBAB, *Adannsonia digitata Linn.* Published in 2002 by International Centre for Underutilised Crops. University of Southampton, SO17 IBJ

Wilsons Biofuel, 2006. Making your own biodiesel. http://climatechange.gc.ca/.doid3452 23 June, 2008.

SUB-THEME 3



Forest Ecosystems, Biodiversity and Wildlife Conservation

Model for Predicting Growth Space Requirements for *Parkia biglobosa* (Benth) Plantation in Kano, Sudan Savanna Vegetation Zone in Nigeria

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ABSTRACT

Parkia biglobosa (Benth) tree species is a multipurpose tree species used by rural communities in Nigeria, and this exposes it to degradation and a regeneration problems. There is lack of information on inventory for P. biglobosa (Benth) in term of plantation establishment and management. This tree species is facing a regeneration problem and overexploitation. These have led to decline in population and the loss of biological values (genetic hereditary). A total of nine blocks as sample plots sizes 100 x 100 meters each was randomly laid down. Simple random sampling technique was used to collect data on tree height, diameter at breast height (dbh), diameter at the base, middle, top (using diameter tape) and crown diameter (using 30 meter measuring tape). The data collected were tested on seven crown and stem diameter relationship models. The linear model (crown-stem diameter relationship) provided the best model fitted with R^2 values of 0.653 to 0.824 species. The results shows that a dominant free-growing tree species with diameter 55.40cm would require 0.009 hectare of growing space with a limiting stocking of the stand in terms of total occupancy by tree crowns of 115 trees per hectare. For optimum planting distance, fast growth and high production/yield; P. biglobosa would require a planting spacing of 4 x 4 meters. Thus, the baseline information from this study could serve as a guide for optimum planting distances and tree density in large scale plantations of native trees species in northern Nigeria and many other countries in African with similar species and forest types.

Keywords: Crown diameter, bole diameter, growth space, models, indigenous species

INTRODUCTION

Parkia biglobosa (Benth) is found in a wide range of environments in Africa including Nigeria. It is a dicotyledonous angiosperm, belonging to the family *Fabaceae* (Alabi, 2005). The plant is categorized under vascular plants (Thiombiano *et al.*, 2012). It is a deciduous perennial plant that grows up to between 7 and 20 meters height in some cases up to 30 meters (Ntui *et al.*, 2012). The tree is a fire-resistant, characterized by a thick dark grey-brown bark; the pods of the tree, commonly referred to as locust beans, are pink in the beginning and turn dark brown when fully mature. They are 30-40cm long on average, with some reaching lengths of about 45cm in length. Each pod can contain up to 30 seeds.

Parkia biglobosa (Benth) species has several uses, including fodder, food, medicine, green manure, fuel wood, timber and economic purposes (Elly and Joseph, 2012). The yellow pulp, which contains the seeds, is naturally sweet and is processed into a valuable carbohydrate food known as *sikomu* and *daddawa* among the Yoruba and Hausa people of Nigeria, respectively (FAO, 2013). The cultivation of this tree can be seen as an important economic activity for many in Africa, both men and women are equally responsible for the sale of dry seeds (Teklehaimanot, 2004). Indigenous healers in Africa use different parts of the locust bean tree for health benefits. In a survey conducted on healers in Togo, *P. biglobosa (Benth)* was one of the highest cited plants used for treating hypertension (Karo *et al.*, 2011). The tree was also one of two plants listed as having real wound-healing properties in South-Western Nigeria, influencing the proliferation of dermal fibroblasts significantly (Adetutu *et al.*, 2011). In a similar survey conducted in Guinea relating to their use of anti-malarial plants, *P. biglobosa* was cited among those most often successfully used (Traore *et al.*, 2013).
The estimation of growing space, establishment and sustainable management of *P. biglobosa (Benth)* species in Kano, require reliable models to determine stand density and stocking of the tree species. Growth space idea has been employed in growth modeling studies, based not only on its measure as the ground area or resources available to individual trees, but also as an indication of competition (Foli *et al.*, 2003; Zuhaidi, 2009). Therefore, growing space simply refers to the adequate resources required within a given area or unit of land for the germination, emergence, growth and development of tree species. An inadequacy of any of these resources needed by individual trees in a stand may limit the growing space and hence affect tree growth (Foli *et al.*, 2003).

The population of *P. biglobosa (Benth)* species is rapidly declining, and there are no conservation efforts to prevent it from extinction (Dau and Chenge, 2016). The continuous removal of this tree species (forest ecosystem) could affect the rural dwellers directly or indirectly because of the species economic and ecological values. The aim of this study was to develop models for growth space requirements for *P. biglobosa* (Benth) species in Kano for establishment and proper management of species plantations for timber and non-timber forest products purposes. Thus, present study on growth space for the species, its present structure, growth and yield would be of great importance to rural communities and to forests managers for optimum planting distance to ensure sustainable species management.

MATERIALS AND METHOD

Study Area

The study was carried out on *Parkia biglobosa* (Benth) in Kano-Nigeria. It lays between Latitude 12^{o} 25^{1} N and 12^{o} 40^{1} N and Longitude 8^{o} 35^{1}E and 8^{o} 45^{1}E. Kano state is located in the Northwest geo-political zone (Sudan savanna vegetation) of Nigeria. Hausa and Fulani, who are predominantly Muslims, inhabit Kano State. The State is having a population of about 9,383, 682 (NPC, 2006). It has 44 Local Governments, with an area of 20,479.6 km^2. The annual rainfall is between 75mm to 1000 mm in the Northern part and increases to 1,120mm in the Southern part of the state. The rainy season lasts within the months of May to October. The topography is of high-level for a few hills in the Southern part.

Measurement Procedures

P. biglobosa (Benth) was selected based on its economic values to rural communities. Simple random technique was used to locate nine sample plots sized 100 x 100 m each within the study area. Complete enumeration of trees greater than 10 cm diameter at breast height (dbh) was assessed and the measurements of the parameters of interest were taken. The data collected on every sampled tree includes: crown diameter by using 30-meter measuring tape; diameter at breast height (dbh), base, middle and top (with the help of portable ladder). Diameter of the sampled trees was determined with the use of diameter tape on winding the tape around the tree at point of measurement (1.3 m) above the ground on the uphill side of the tree. Total height was measured by using *Haga altimeter* (Dau and Chenge, 2016).

Crown-diameter measurement was based on the assumption that the vertical projection of a tree crown is circular; four radii were measured (using 30-meter measuring tape) and in the direction forming equal angles (Foli *et al*., 2003*; Zuhaidi*, 2009). Along each radius of the tree crown, the diameter tape was held horizontally and extended until each person was vertically under the tip of the longest branch on both sides; a 3.00 - meter ranging pole was used to align vertically to the edge of the crown (Dau and Chenge, 2016). The diameter tape was turned by 90^{o} and measurements were carried out repeatedly along the thinnest part of the tree crown and recorded (Foli *et al.*, 2003). Average crown diameter (Cd) was calculated by summing up the four radii and divided by 2.

Data Analysis

Basal area estimation

The diameter at breast height (dbh) was used to compute basal area using the formula:

$B.A = \pi D^2 / 4$ ……..Equation (1) (Foli *et al.,* 2003)

Where: BA = Basal area (hectare); D = Diameter at breast height (m) and $\pi = 3.142$

Crown-diameter

The data collected from the field were fitted to the following model forms for predicting crown diameter suggested by different authors with the aim of choosing the model form that showed the best ability to stabilize the variance in the data:

- $Cd = b_o + b_1\, dbh + ei$ Equation (3a) (Brian *et al.*,2005)
- $Cd = b_o + b_1\, dbh^2 + ei$ Equation (3b) (Foli *et al.,* 2003)
- $Cd = b_o + b_1\, dbh + b_2 \ln dbh + ei$ Equation (3c) (Dau & Chenge, 2016)
- $Cd = b_o + b_1 \ln dbh + ei$ Equation (3d) (Zuhaidi, 2009)
- $\text{Ln}Cd = b_o + b_1\, dbh^2 + b_2\, \text{Ln}dbh^2 + ei$ Equation (3e) (Foli *et al.,* 2003)
- $\text{Ln}Cd = b_o + b_1 \ln dbh + ei$ Equation (3f) (Dau & Chenge, 2016)
- $\text{Ln}Cd = b_o + b_1 dbh^2 + b_2\, \text{Ln}dbh + ei$ Equation (3g) (Zuhaidi, 2009)

Where: Cd = crown diameter; dbh = diameter at breast height; b_0 = intercept, b_1 and b_2 = regression coefficient

Crown Area

Using the calculated crown diameter (Cd), the crown area (A) was estimated and expressed in hectare basis (conversion of crow diameter in meters to area in hectares):

$A = (\pi Cd^2/4) / 10{,}000$ …… Equation (2) (Foli *et al.*, 2003)

Where: A = growing space/area; **Cd** = crown diameter; $\pi = 3.142$

$N = 1/A$ i.e. $[1/(Cd^2/4)/10{,}000]$…….. Equation (3) (Kunluvainen, 1991; Philip, 1994; Dau & Chenge, 2016)

Where: N = stock; A = growing space

Stand density/ Basal area per hectare

$S.D = \pi D^2 / 40,000$ ……..Equation (4) (Zuhaidi, 2009).

Where: SD= stand density; D= diameter; $\pi = 3.142$.

Criteria for Models Selection and Ranking

The models were fitted and assessed. The assessment was based on all the following criteria: the significance of regression equation (F-ratio), coefficient of determination (R^2), root mean square error (RMSE) and normal probability plots of residuals (Onyekwelu, 2005; Dau & Chenge, 2016). The best model was selected based on a ranking procedure, for each model ranking was based on the above mentioned criteria. The model with the highest F-ratio/R^2 was assigned a rank of one while model with the lowest F-ratio/R^2 was assigned a rank of seven; the model with best fitted residual/normal probability plots and lowest RMSE was assigned a rank of one. Then the rank for R^2, RMSE, F-ratio, residual and normal probability plots were combined, and were then summed to determine the most appropriate model (Kozak and Smith 1993; Mohamed and Ahmed, 2014). T-test was used to test for significant difference at $p \leq 0.05$ level of significant; 30% of data from the tree species were used (independent of those used to develop the model) for the purpose of validation (Dau & Chenge, 2016).

RESULTS AND DISCUSSION

Figures 1a and 1b show the class distribution of bole diameter and crown diameter. Based on this finding, there was more concentration of stem diameter at the upper diameter class (15.00 – 40.00 cm) than in the lower diameter class distribution (41.00 – 50.1 cm). This may be as a result of high exploitation or mortality on the tree species. The result on the crown diameter class can be used as an important visual indicator of tree and forest trend (healthy or unhealthy) in the study area. Trees with full and healthy crowns are generally associated with higher growth rates as a result of an increased rate for photosynthesis. These results described the current status/trends and condition of *Parkia biglobosa* (Benth) species in the area as summarized in Figures 1a and 1b. The figures revealed the crown condition of the study area which was healthy and free from high competition. This may be as the results of low population (declining in population due to deforestation without reforestation) of the tree species (open grown trees) or the soil condition of the area. The result is in accord with (Lawrence, 2002. who stated that crown degradation is typically the result of past and present stressors such as insects, diseases, weather events, drought, senescence, and competition or other stand conditions and when severe enough, may result in tree mortality.

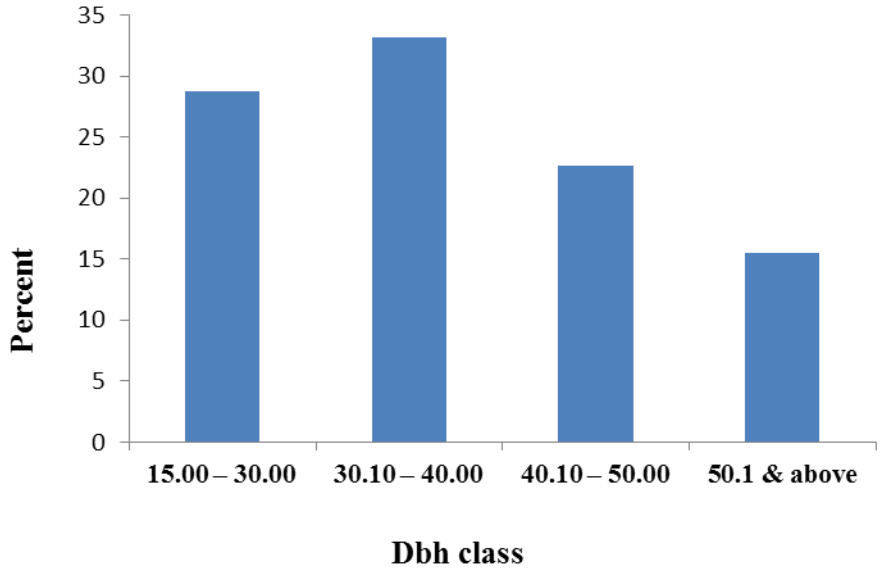


Figure 1a: Bole-diameter Distributions of *Parkia biglobosa* (Benth) Trees in Kano State

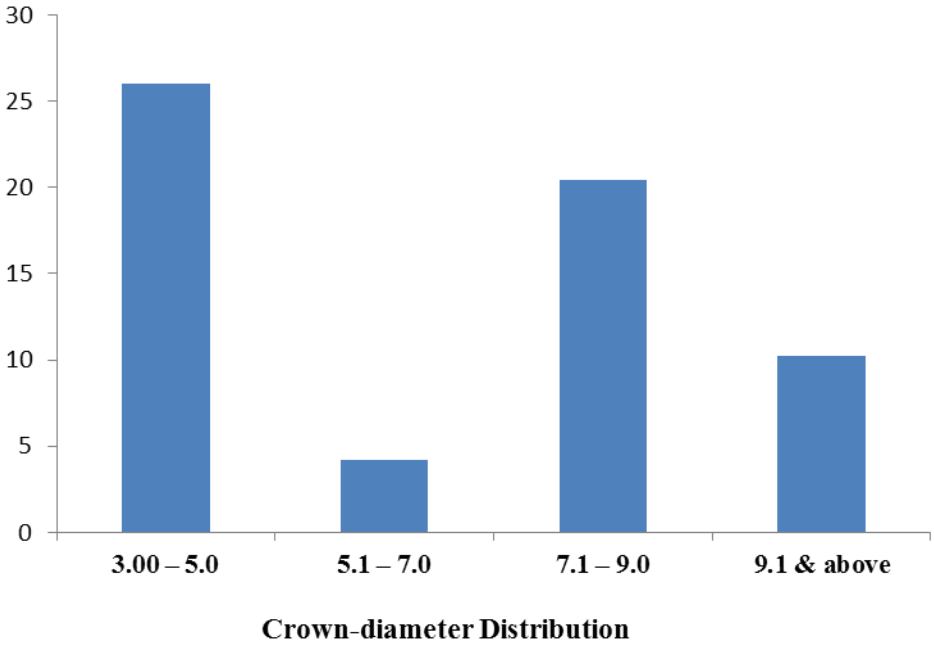


Figure 1b: Crown-diameter Distributions of *P. biglobosa* (Benth) Trees in Kano State

Table 1 summarized the regression parameters on ***P. biglobosa (Benth)*** trees. Coefficients of determination (R^2) ranged from 0.653 to 0.825. RMSE was used to compare untransformed models while *F.I* was used to compare the transformed models.

Table 1: Summary of regression parameter on *P. biglobosa (Benth)* Trees in Kano State

Model No.	Model type and model coefficients	R^2	Adj. R^2	RMSE	F-ratio	FI
[3a]	$Cd = 2.134 + 0.126\ dbh$	0.824	0.823	0.710	1226.7	-
[3b]	$Cd = 4.895 + 0.001\ dbh^2$	0.764	0.763	0.822	851.06	-
[3c]	$Cd = -1.805 + 0.91\ dbh + 1.459 \ln dbh$	0.825	0.824	0.709	617.83	-
[3d]	$Cd = -11.93`1 + 5.242 \ln dbh + ei.$	0.815	0.814	0.728	1155	-
[3e]	$\text{Ln}Cd = 0.123 - 0.00004\ dbh^2 + 1.35\ \text{Ln}dbh^2$	0.655	0.652	0.173	248.67	0.0608
[3f]	$\text{Ln}Cd = -1.129 + 0.814 \ln dbh$	0.653	0.651	0.173	494.05	0.0608
[3g]	$\text{Ln}Cd = -1.304 + -1.479 dbh^2 + 0.869\ \text{Ln}dbh$	0.653	0.650	0.173	246.50	0.0608

dbh =Diameter at breast height(cm);=Coefficient of Determination; RMSE= residual mean square error; FI=furnival index.

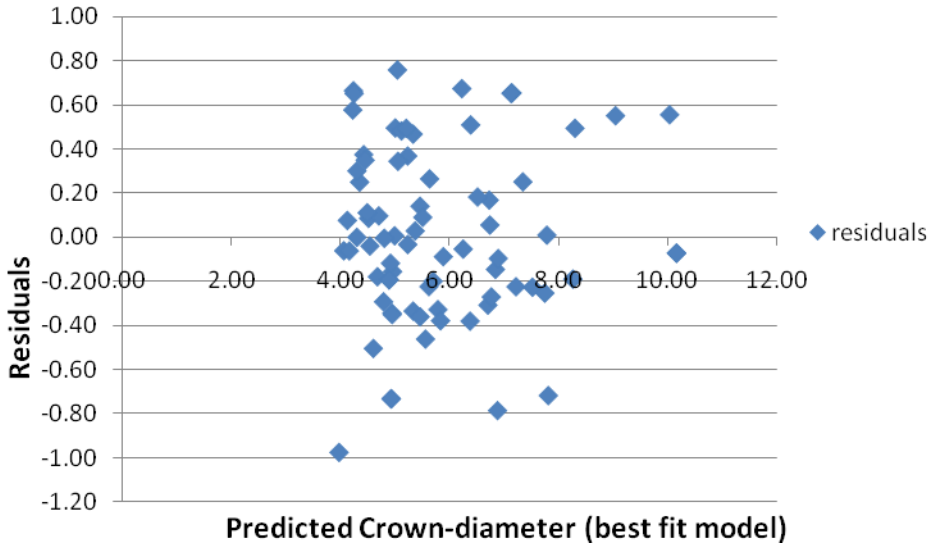


Figure 2: Scatter plot of Residuals and Predicted crown-diameter for *P. biglobosa (Benth)* Trees in Kano State-Nigeria

Crown-diameter and Stem-diameter Relationships

Table 1 shows results on linear, power, natural log regressions for the tree species. The coefficients of determination differ among the models within the species in this study area, this may be attributed to the fact that almost all the sample trees were small in sized with relatively small crown diameters (Figures 1a and 1b). The results in Table 1 significantly explained the variation in crown diameter and correlated well with tree diameter (model 3a). The Furnival indexe (RMSE) of the estimates of crown-diameter were low enough to make models 3e, 3f and 3g sufficiently reliable for predicting crown-diameter from stem-diameter but the F-ratios and R^2 were very low with negative coefficient in model 3e (– 0.00004) and intercepts in models 3f (-1.129) and 3g (-1.304 and +0.869). The coefficients of the regression were positive and significant different in models 3a and 3b. R^2, RMSE and F-ratio were better in model 3a (Table 1). A comparison of the residual plots (i.e. normal probability plots, histogram and scatter plots) tended to favour models 3a and 3b which are fairly fitted and better than the other models under studied.

Based on the result obtained, the regression analysis results (Table 1 and figure 2) showed that crown diameter was better correlated with bole diameter in model 3a. Thus, linear model (model 3a) was the best model because the model conformed to assumptions of regression analysis with positive coefficients, couple with its superiority in past research (Foli *et al.*, 2003). When the linear models (model 3a) was validated by the used of T-tests. P-values revealed no significant difference between the observed (measured crown diameter) and predicted (crown diameter values) with the Pearson correlation coefficients of 0.97. This showed a close correlation between the observed and predicted crown diameter values. When the observed data were compared with predicted values using the best models for each of the selected species, the T-tests revealed no significant differences (p = 0.31 one-tail and 0.63 two-tail).

Table 2: Estimated crown diameter (CD), Growing space (S), Stocking (N) and Stand density (D) from the modeling (model 4) in Kano, Nigeria

Dbh (cm)	Cd (m)	Cd/dbh	S (ha)	Nha^{-1} (1/S)	D (m^2ha^{-1})
18.30	3.20	0.175	0.001	773	2.6302^{-06}
25.40	4.70	0.185	0.002	454	5.0670^{-06}
31.10	5.90	0.190	0.003	322	7.5964^{-06}
40.20	7.70	0.192	0.005	206	1.2692^{-05}
45.10	8.85	0.196	0.006	167	1.5975^{-05}
55.40	11.90	0.215	0.009	115	2.4105^{-05}
65.70	12.70	0.193	0.012	84	3.3901^{-05}
70.20	12.90	0.184	0.013	74	3.8704^{-05}
75.70	13.40	0.177	0.015	65	4.5007^{-05}
81.80	13.80	0.169	0.018	56	5.2552^{-05}

The above table was derived from the crown-diameter and stem-diameter regressions, and was computed as follows:
Cd= 2.134 + 0.126 dbh; Growing space (S) = $Cd^2 \pi$ /40 000 and limiting stocking (N) = 1/ S.
Growth space requirements for *P. biglobosa* species was determined based on the findings by (Foli *et al.,* 2003), who stated that growth space was associating with crown size. Therefore, using the calculated crown diameter (Cd), the crown area (A) for each tree species was estimated and expressed in hectare basis (Table 2); to improve production, fast growth and quality of tree species in the study area, individual tree species in a stand must have unrestricted continuous free-growing space; this requires idea and insight of maximum occupancy [limiting stock] of sites with time. Thus, equations 5and 6 were used to estimate the growing space and stand density for the tree species in Kano-Nigeria; the results also provide a means of estimating the limiting stocking per hectare (N ha^{-1}) required for producing a complete canopy (i.e. to fully occupy the site). This can be expressed as inverse of the growing space as are summarized and showed in table 2.

The results in table 2 showed that a dominant free-growing tree species of diameter 55.4cm would require a growing space of 0.009 ha and limiting stocking of the stand in terms of total occupancy by tree crowns of 115 trees per hectare. The results from the models for growth space requirements showed that the models were more elastic between 1.30 and 55.4 cm and gradually decreased as the diameter size increased (Table 2).

The crown-stem diameter ratio is a measure of the efficiency of a tree to accumulate diameter at breast height per unit of crown area. The higher the ratio, the more efficient a tree species is at accumulating dbh (Brian *et al.,* 2005). The results on ratio shown that for each meter of crown diameter in *Parkia biglobosa* species, 0.215 cm of stem diameter was accumulated as the highest efficient without serious crown interference or competition. Data in the present study represent a wider range of diameter classes (Figures 1a and 1b).

For fast growth and high production, *P. biglobosa* (benth) species would require planting spacing of 4m. x 4 m. This spacing could lead to reduction of mortality and would increased total production per unit area in a given period of time. Stands with wider spacing in time, have larger average stem and crown diameter than similar stands with closer spacing. From table 2, the tree species would required low densities for optimum planting, fast growth and high yield for the purpose of timber and non-timber forest products. This result agreed with Clutter *et al*. (1983), who stated that very low densities are required to produce maximum diameter growth throughout the life of an even-aged stand.

CONCLUSION AND RECOMMENDATION

Crown diameter and bole dbh relationship has been studied. Crown diameter can be predicted from the measurement of tree dbh. Based on the result obtained, *P. biglobosa (Benth)* trees would require growth planting spacing of 4 m x 4 m for plantation establishment in the study area for the purpose of non-timber forest products, fencing pole and electricity pole. However, for the timber purpose, silvicultural practices (thinning and selection felling) can be applied to the plantation to create more space for diameter increase and growth. The recommended planting spacing would enhance optimum planting and control competition within the tree species for purpose of plantation establishment.

REFERENCES

Adetutu, A., Morgan, W., and Corcoran, O. (2011): Ethnopharmacological survey and in vitro evaluation of wound-healing plants used in South-western Nigeria. *Journal of Ethnopharmacol*, 137(1); Pp. 50-56.

Alabi, D. A, O. R. Akinsulire, and M. A. Sanyaolu, (2005): *African Journal of Biotechnol*; Vol. 4; Pp. 812-815.

Brian R. L., Robert C. W., and Keith, M.S. (2005): Crown Radius and Diameter at Breast Height Relationships for Six Bottomland Hardwood Species. *Journal of the Arkansas Academy of Science;* Vol.59; Pp. 110-115

Clutter, J.L., Fortson, J.C., Pienaar, L.V., Brister, G.H., Bailey, R.L., (1983): Timber Management: A Quantitative Approach. Wiley, New York, P. 333.

Dau, J. H. and Chenge, B. I. (2016): Growth space requirements models for *Prosopis africana* (Guill & Perr) Taub Tree Species in Makurdi, Nigeria; Research Article, *European Journal of Biological Research*; Vol. 6 (3); Pp. 209-217

Elly, N.S. and Joseph C. (2012): *Parkia Biglobosa:* A Pot ential Multipurpose Fodder Tree Legume in West Africa. *International Tree Crops Journal*; Volume 7, Issue 1992; Published online: 05 Apr 2012; DOI: 10.1080/01435698.1992.9752911; Pp. 113-139

Foli, E.G; Alder, D.; Miller, H.G. and Swaine, M.D. (2003): Modeling Growing Space Requirements for some Tropical Forest Tree Species; *Forest Ecology and Management* 173 (2003); Pp. 79-88; www.elsevier.com/locate/foreco

Jerome, L.C.; James, C.F.; Leon, V.P.; Graham, H.B. and Robert, L.B. (1982): Predicting Growth and Yield; In: Timber Management: a Quantitative Approach; Vol. 1, John Wiley and Sons, Chichester/New York; Pp. 89-138.

Karou, S., Tchacondo, T., Tchibozo, M. D., Abdoul-Rahaman, S., Anani, K., Koudouvo, K. (2011): Ethnobotanical study of medicinal plants used in the management of diabetes mellitus and hypertension in the Central Region of Togo. Pharmaceutical Biology; Vol. 49(12); 1286-1297.

Kozak.A., and Smith J.H.G. (1993): Standards for evaluating taper estimating system. The forestry chronicle,69(4):438-444.

Kunluvainen, T. 1991. Relationship between crown projected area and components of above-ground biomass in Norway Spruce stands; empirical results and their interpretation; Forest Ecology Management, 40; 243-260.

Lawrence, R.; Moltzan, B.; Moser, W.K. [2002]: Oak decline and the future of Missouri's forests. Missouri Conservationist. 63(7): 11–18.

Mohamed O.A. and Ahmed E. (2014): Height Diameter Relationship Model for *Acacia nilotica* in Riverine Forests - Blue Nile; *Journal of Forest Products and Industries*; Vol. 3(1); Pp.50-55 ISSN: 2325–4513(Print) ISSN 2325 - 453x (Online).

N. P. C. (National Population Commission, 2006): Population of local government in Kano state. Federal Government of Nigeria gazette, 2006.

Ntui, V. O., Uyoh, E. A., Urua, I. S., Ogbu, U., & Okpako, E. C. (2012): Regeneration of *Parkia biglobosa Benth*.: An important tree species of Africa. *Journal of Microbiology and Biotechnology Research*, 2(1), 169-177; the Scholar's Research Library database; ISSN: 2231 –3168.

Onyekwelu, J.C. (2005): site index curves for site quality assessment of *Nauclea diderichii* monoculture plantations in Omo forest reserve, Nigeria; *journal of tropical forest science*; 17(4): 532-542.

Phillip, M.S. (1994). Measuring Trees and Forests. CAB International, Wallingford.

Teklehaimanot, Z. (2004): Exploiting the potential of indigenous agroforestry trees: *Parkia biglobosa and Vitellaria paradoxa* in sub-Saharan Africa. *Agroforestry Systems*, 61, 207-220.

Thiombiano, D. N., Lamien, N., Dibong, D. S., Boussim, I. J., & Belem, B. (2012): The role of woody species in managing food shortage in Burkina Faso. *Sécheresse*, 23(2), Pp. 86-93.

Traoré, M., Baldé, M., Oularé, K., Magassouba, F., Diakité, I., Diallo, A. (2013): Ethnobotanical survey on medicinal plants used by Guinean traditional healers in the treatment of malaria; *Journal of Ethnopharmacol*, S0378-8741(13)00773-3. 10.1016/j.jep.2013.10.048.

Zuhaidi, Y. A. (2009): Local Growth Model in Modeling the Crown Diameter of plantation-Grown *Dryobalanops aromatic; Journal of Tropical Forest Science* 21(1); Pp.66-71.

Effects of Sowing Media and Sowing Depth on the Germination of *Monodora tenuifolia* Benth

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ABSTRACT

This study examined the effect of sowing media and sowing depth on the germination of Monodora tenuifolia Benth. Seed germination of Monodora tenuifolia was significant on sowing depth at p=0.05 but not significant on sowing media. The result of various sowing media and sowing depth showed that the seed sown at 3 cm depths in topsoil had the highest germination percentage of 30%. This was followed by surface sowing in both river sand and topsoil with 22% and the least germination percentage was found at 6 cm depth in sawdust with 2 %. It was then observed from the study that the seeds of Monodora tenuifolia can be best propagated in topsoil at 3 cm depth.

Keywords: *Monodora tenuifolia*, topsoil, sawdust, river sand and percentage germination

INTRODUCTION

A suitable sowing media is important for the production of quality plants seedlings. As it affects the development of plant directly and later affect the maintenance of the extensive functional rooting system. A good sowing medium provides required support to the plant, permit gaseous exchange between the roots and atmosphere outside the root substrate, serves as reservoir for nutrients and water and allow oxygen diffusion to the roots (Abad *et al.*, 2002). It was reported by Nwoboshi, (1982) that the soil depth available for rooting is a major physical soil factor in silviculture. Soil utilization can be limited shallowness of the soil which can restrict the supply of moisture, air and availability of nutrients to forest stands. Thus, depths at which seeds are sown into the soil affect the germination of these seeds, and subsequent seedling growth (Bockus and Sholberg, 1996). Some seeds germinate well on the soil surface while others require a little or more depth into the soil.

However, a rule of thumb is to sow seeds approximately three to four times the diameter of the seed, making sure that seeds are in the upper most layer of the soil (Hudson and Dale, 1975). On the other hand, Harries *et al*. (1998) stated that sowing depth is generally twice the diameter of the seed. *Monodora tenuifolia* Benth belongs to the family Annonaceae which is also called 'Custard – apple' family (Kral, 1960). The species is being referred to in English as 'African nutmeg' (Burkill 1985) and 'Ehuru ofia' in Igbo. It is a shrub that usually grows into a medium sized forest tree and the shape of the Canopy is usually determined by its branching pattern (Azeez *et al.*, 2014). It is mostly found in the forest regions of East Indies, West Indies, Malaysia, SriLanka and Africa. Talaji (1965), reported that it is very common in Nigeria

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M. tenuifolia has been identified by Adeoye *et al.* (1986), to have both antifungal and antibacterial metabolites. It is also used to reduce toothache, dysentery, dermatitis, headache and as vermifuge. The seeds are aromatic and used as ingredient in herbal medicines in southern Nigeria and are also used as spice and flavor in food (Irvine 1961 and Oguntimein *et al.*, 1989). However, despite all the medicinal importance of most plants species like Monodora, yet it has become increasingly impossible to establish most of their plantation due to difficulties encountered in the collection and storage of viable fruits. This has actually made the multiplication of this species a more pressing need because of its numerous medicinal values. Therefore, this study looked into the rate of germination of the seed in different sowing media and its growth at different sowing depth.

MATERIALS AND METHODS

Ripe fruits of *Monodora tenuifolia* were freshly collected from Ile-Ife in Osun state, Nigeria and depulped and seeds extracted. The experiment was carried out at Tree Improvement section nursery of Sustainable Forest Management Department in the premises of Forestry Research Institute of Nigeria (FRIN). It lies between latitude7^{o}24'N and longitude 3^{o}55'E.

Three different sowing media and three different sowing depth were used (top soil, river sand and sawdust also, 0 cm, 3 cm, and 6 cm depth). Total number of two hundred and forty seeds was used in the experiment. Eighty seeds were allocated to each of the treatment and each treatment was replicated four times. Germination commenced a week after sowing, and germination record was taken.

RESULTS AND DISCUSSION

Effect of Sowing Depth on Seed Germination

Optimum sowing depth requirements is exhibited by plants based on the type of seed and the environmental conditions (Agboola 1996, McWilliam *et al*. 1998). Typical example is mangrove species which shows vivipary. The seed germinates inside the fruit while it is still on the parent tree and also nourished by it. The seedling develops on the parent tree, and on falling, the radical press into the mud environment, (Dutta, 2003). Seed germination of *Monodora tenuifolia* was a hypogeal type where the seed first germinated below the ground first because the cotyledon is fleshy and contain enough nutrients trequired for germination without photosynthesized (Ferreira and Junk, 2003). The result revealed that there was significant difference among the sowing depth (Table 1). It was deduced from Table 2 that the interaction between the sowing medium and sowing depth had the highest germination percentage of 30 % at 3 cm depth in top soil. This was followed by seedlings sown in both topsoil and river sand at 0 cm depth with 22 % germination. The least germination percentage was recorded in sawdust at 6 cm depth with 2 %. The seeds sown at 3 cm depth which was very close to the surface had the highest mean value of 0.9289 in topsoil while the seeds sown at 6 cm depth which was the deepest among all the depth in the experiment had the lowest mean value of 0.0753 as shown in Table 3. The result is in agreement with the result of Abdulkareem and Ahmed (2008) where two depths (6 cm and 12 cm) were used for the germinaton of chickpea (*Cicer arietinum*). The plants sown in the deepest depth had the lowest germination count compared to the other depth. Haque *et al.* (1992) who obtained a greater seedling emergence rate of rice (Oryza sativa) in seedbeds with coarse aggregates and concluded that crop establishment was not affected by soil structure. According to Diaz-Zorita *et al.* (2005), and Cernac *et al.* (2006) they stated that germination and seedling emergence is independent of soil nutrient status, but rather depends totally on the cotyledons still attached to the seedling which are rich in stored food reserves until the seedling becomes autotrophic and the ability of the seedlings to utilize these food reserves. Seed germination of *Monodora tenuifolis* was not significantly affected by sowing medium at p=0.05 (Table 4).

Table 1: Mean Value of Variation among the Depth of *Monodora tenuifolis*

sowing depths	N	Subset	
		1	2
6cm depth	12	.2455	
3cm depth	12		.5728
0 depth	12		.7520
Sig.		1.000	.080

Table 2: Interaction between sowing media and sowing depth

	Depth in Percentage		
	0 cm	**3 cm**	**6 cm**
Topsoil	22	30	0
River sand	22	0	18
Sawdust	19	21	2

Table 3: The Mean Values of the Experiment

sowing media	sowing depths	Mean
Topsoil	0 depth	.7654
	3cm depth	.9287
	6cm depth	.0000
	Total	.5647
Riversand	0 depth	.7918
	3cm depth	.0000
	6cm depth	.6611
	Total	.4843
Sawdust	0 depth	.6988
	3cm depth	.7896
	6cm depth	.0753
	Total	.5212
Total	0 depth	.7520
	3cm depth	.5728
	6cm depth	.2455
	Total	.5234

Table 4: Mean Values of Variation among the Sowing Media of *Monodora tenuifolis*

sowing media	N	Subset
		1
Riversand	12	.4843
Sawdust	12	.5212
Topsoil	12	.5647
Sig.		.449

CONCLUSION AND RECOMMENDATION

It was observed from the study that natural regeneration of *Monodora tenuifolia* is possible through dispersal by rodents or other animals that may feed on its fruits and release the seed as surface sowing, since *Monodora tenuifolia* can be sown at the surface level (0 cm depth) and also at 3 cm depth. It was made clear from the study that sowing of seed too deep in the ground may result in failure of the seed to germinate, since seed has only food reserve for limited period of growth and when sown deeply more than necessary, it soon expends that food or energy and dies before it reaches the surface.

Therefore, 3 cm depth is recommended for sowing this species while topsoil can be used as its germination media. However, for optimum seedling germination for the purpose of plantation establishment, seedlings raised with humus rich top soil is recommended.

REFERENCES

Abad M, Noguera, P., Puchades, R., Maquieira, A, Noguera, V. (2002): Physico-chemical and chemical properties of some coconut dusts for use as a peat substitute for containerized ornamental plants. Biores. Technol. 82:241-245.

Emenky, F.A.O. and Khalaf, A.S., (2008): Effect of sowing depths and seed size of some Winter Cultivars of Chickpea (*Cicer arietinum* L.) on Field Emergence and Vegetative Growth. *Research Journal of seed Science*, 1: 11-18

Azeez, S.O., Faluyi, J.O. and Oziegbe, M., (2014): Botanical and Cytological studies of *Monodora tenuifolis* Benth. *Journal of Notulae*. Scientia Biologicae. 6(2), 173-177.

Agboola, DA. 1997. Effect of storage humidity, seed longevity and sowing depth on seed germination of *Prosopis africana* (Guill and Perr.) Taub. *Bangladesh Journal of Forest Science*. 25(1-2):65-70.

Bockus, W.W., Sholberg, J.P. (1996): Effect of seed size on seedling vigour and forage production of winter wheat. *Canada Journal of Plant Science* 76):101-105.

Cernac, Alex, Andre, C., Hoffmann-Benning, S. and Benning, C., 2006. WRI1 is required for seed germination and seedling establishment1. Plant Physiology 141: 745-757.

Diaz-Zorita, M., Grove, J.H. and Perfect, E. 2005. Soil fragment size distribution and compactive effort effect on maize root seedling elongation in moist soil. Crop Science. 45: 1417-1426.

Dutta, A.C., (2003): Botany for Degree Students. Sixth Edition, Oxford University Press.

Burkill, H.M., (1985): African Nutmeg. The Useful plants of Tropical Africa Vol 1. Royal Botanic Garden, Kew. England: Scientific Publications Department, Royal Botanical Gardens.

Parolin, P., Ferreira, L.V., Junk, W.J., (2003): "Germination characteristics and establishment of trees from central Amazonian flood plains" *Tropical Ecology* 44(2): 157-169

Harries, P. P., and Erik, S., (1998): Propagating and planting trees. *Agrodok Series* Hartmann, H.T.; Kester, D.E. and Davies, F.T Jr. (1990): Plant Propagation: Principles and Practices. 5th ed. Regents/ Prentice Hall, Inc., Englewood Cliff. New Jersey. P.73.

Hudson, T.H. and Dale, E.K., (1975): Plant propagation: Principles and Practices 3rd Edition, Prentice-Hall. P.662. Amason, USA.

Haque, A., Hamid, A., Islam, M.T. and Mohinddin, M. (1992): Seedbed characteristics and seedling depth effect on emergence and seedling vigour of upland rice. Journal of Agronomy and Crop Science 168: 61-64.

McWilliam, S.C., Stokes, D.T. and Scott, R.K. (1998): Establishment of oilseed rape: the influence of physical characteristics of seedbeds and weather on germination, emergence and seedling survival. HGCA Project Report No. OS31. 99 p.

Kral, R. (1960): A revision of *Asimina* and *Deeminpothamnius* (Annonaceae) Prithonia 12(4):233-278.

Irvine, F.R., (1961): Woody Plants of Ghana with Special Reference to Their Uses. 2nd Edition., Oxford University Press, London.

Adeoye, A.O., Oguntimein, B.O, Clark, A.M. and Hufford, C.D., (1986): 3-Dimethylallylindole: an antibacterial and antifungal metabolite from *Monodora tenuifolia*. J Nat Prod 49:534–537.

Oguntimein, B., Ekundayo, O., Laasko, I. and Hitunem, R., (1989): Constituents of the essential oil of *Monodora tenuifolia* Flav Frag 4:193-195.

Nwoboshi, L.C., (1982): Tropical Silviculture, Principles and Techniques, Department of Forest Res. Mgt., University of Ibadan, Nigeria. University Press. P. 333.

Talaji, S.J., (1965): Essential oil from *Monodora myristica* grown in Ghana. West Afr Pharm 4:64-65.

Response of Selected Hybrid Silkworm *Bombyx mori* (Linnaeus) fed with Varieties of Mulberry *Morus alba* Leaves

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ABSTRACT

The response of three hybrid silkworm Bombyx mori (EC1×EJ1,EC1×EJ2, EW1×EW2) fed with four varieties of mulberry (Morus alba) leaves (S30,S14,S41,S54 varieties) were investigated. The experiment was laid out in a Randomized Complete Block Design (RCBD) replicated three times. The data collected was subjected to analysis of variance using Duncan Multiple Range Test (DMRT) to separate the means where significant. The effect of the mulberry leaves on the silkworm, EC1×EJ1 shows that S14 has the highest value of larvae weight (MLW) 5.77g and pupae weight (MPW) 10.63g while S30 has the least MLW 2.83g and MPW 8.67g. EC1×EJ2 hybrid, shows that S54 has the highest MLW 3.92g while S14 has the highest MPW 9.66g. The least MLW value 3.15g and MPW 8.20g was recorded with S30. EW1×EW2 has the highest MLW of 4.07g with S54 and MPW of 10.33g with S14. The least MLW 3.84g and MPW 8.57g was observed with S30.On cocoon parameters, EC1×EJ1 has the highest values of 77% as percentage of cocoon formed (PCF), 90.73g cocoon weight (CW), 86.77g deflux cocoon weight (DCW) and 462.25m filament length (FL) with S54. The least mean of 49% PCF, 57.85g CW and 49.80g DCW with S30 while S41 has the least value of 319.48m FL. EC1×EJ2 has the highest PCF 87%, CW 104.23g,and DCW 100g with S14 while S54 has the highest FL 620.36m. The lowest PCF 48%, CW 52.60g, and DCW 45.57g were obtained from S54 while S30 had the lowest FL 300.88m. EW1×EW2 gave the highest mean PCF 55%, CW 67.33g, DCW 63.53g, and FL 840.30m with S54. The least PCF 42%, CW 52.15g, DCW 44.33g with S30 while S41 has the least FL 424.54m. On the overall analysis, S54 had the best performance among the varieties examined and silkworm hybrid EW1×EW2 gave the highest cocoon quantity and quality, and are therefore recommended for sericulture in Nigeria.

Keywords: Cocoon, variety, silkworm, hybrid

INTRODUCTION

From time immemorial, sericulture has been playing a very important role in the economic activities of nations such as China, India and several others where it was later introduced (Sanchez, 2002). Sericulture involves rearing of silkworm larvae (*Bombyx mori*) as well as the cultivation of mulberry plant (*Morus alba*) for silkworm feeding. *Bombyx mori* is the domesticated species of wild *Bombyx mandarina* and this insect which can no longer survive in the wild has been genetically modified to feed only on mulberry leaves. *Bombyx mori* undergoes a complete metamorphosis from egg to larvae through pupae and moth or adult stage. The domesticated variety compared to the wild form has increased cocoon size, growth rate and efficiency of its digestion. It has also gained tolerance to human presence and handling. It also cannot fly and lacks fear of potential predators. These changes have made it entirely dependent upon humans and on mulberry leaves for their survival (Geetha,2007). Mulberry plant belong to the family Moraceae and is a widespread and very important crop for silkworm feed, fruit, and timber as well as being an excellent animal feed and are used as by-product (Datta, 2002). Silkworm mulberry has been cultivated as silkworm feed in china for very long time. Wang zichum (1987) indicates that silkworm culture existed in China 4,000 years ago or earlier. It is widely grown since silkworms rearing (sericulture) and it becomes very important to the third world countries. The mulberry sericulture industry is facing several problems in Nigeria which have restricted full utilization of its potential. The quality and quantity of cocoon production in Nigeria is very low when compare to other developed country like china and India. *Morus alba* is a tree which can reach over 20m in height but in its cultivated form, is often coppiced, pollarded, or pruned to a low growing bush to facilitate the harvesting of leaves. The form of the tree can vary from

pyramidal to drooping and the tree generally has a deep tap root, deciduous in temperate and sub-tropical climates while they are in leaf throughout the year under tropical upland conditions (Charles, 2006).

In Nigeria today, rural poor are ever- increasing and this has led to urban overcrowding which in turn has led to social problems and infrastructural decay in most Nigeria cities as a result of massive rural-urban drift in search for job opportunities which are not readily available in the cities, yet sericulture is a wide subject of varying importance in that it is an agro-industrial rural vocation which is farmer-friendly and suitable for rural masses, but little or no research is being carried out on sericulture and even where researches are done, many Nigerians are yet to be aware of the numerous potential of silkworm rearing. This sector is capable of alleviating poverty in the country through the provision of jobs for unemployed masses as well as generating foreign exchange through export. It provides raw material for the production of textiles, winery cosmetics, pharmaceuticals, lawyers wig and carpet (Ashiru, 1997). Thus, this experiment which looked into the response of some selected silkworm hybrid to different varieties of mulberry leaves seeks to bring sericulture into a limelight.

MATERIALS AND METHODS

Experimental Site

The experiment was carried out at the sericulture laboratory of Forestry Research Institute of Nigeria Jericho hill, Ibadan. It is situated at Jericho quarter in the South-West Local Government Area in Ibadan. The institute is located within latitude $7^{0}23^{1}$N and longitude $3^{0}15^{1}$E with an annual rainfall ranging from 1400mm – 1500mm, the temperature is 32^{0}C and average relative humidity of about 80-85% (FRIN, 2013). The 3 silkworm hybrid used for the experiment were obtained from the sericulture unit of Forest Product Development and Utilization in FRIN include; EC1×EJ1, EC1×EJ2, EW1×EW2 hybrid silkworm (*Bombyx mori*) . The mulberry plot which serves as feed reservoir for the silkworm was divided into 3 sub-plot in each sample plot. Soil auger was used to collect the samples from each point of the subplot. The soils from each point of collection were mixed thoroughly to obtain an homogenous mixture. This was later mixed with soil samples from other subplot in order to obtain homogenous mixture of the whole sample plot. The soil samples were air dried in order to remove the moisture content, before taken to IAR&T laboratory at Moor plantation Ibadan for analysis. The leaves plucked on each varieties of mulberry in FRIN plantation were taken to kappa laboratory at Trans Amusement Park, old airport Bodija Ibadan for proximate analysis. Formaldehyde was sprayed to disinfect the rearing room, and all the materials and equipment. Rearing room and the materials were locked up for 24hrs after disinfection. The rearing trays were cleaned with 5% formaldehyde solution to disinfect the trays before spreading the cellophane paper on the rearing tray. The newly emerged larvae were brushed in different rearing trays for the 3 silkworm hybrid as they emerged from egg shell. Brushing of newly emerged larvae was done with disinfected bird feather, so that they were not injured. (plate 1) Brushed larvae were fed with S30 variety mulberry leaves till the end of 2^{nd} instar stage. Succulent leaves (upper layers) of different varieties were used to feed. The leaves were chopped into smaller sizes with the aid of knife for easy consumption by the larvae. Coolant (foam soaked with water) was placed around the larvae in the rearing tray to maintain a high relative humidity and keep their feed moist. Treatment of different varieties of mulberry which are; S30, S14, S41, and S54 varieties were applied at the commencement of 3^{rd} instar stage. 100 larvae of each hybrid silkworm were counted into rearing trays, for each variety of mulberry leaves which were replicated 3 times. 25g per meal were fed to each replicate 3 times daily (morning, afternoon, and evening). The feed were slightly increased from 25g to 45g and 75g at the 3^{rd}, 4^{th}, and 5^{th} instar stage respectively (plate 2). Bed cleaning was carried out at the end of each moulting period. Bed cleaning involves spreading of net on the rearing trays and allowing the larvae to move up the net, so that waste could be disposed. The rearing room condition was at temperature 25^{0}C$\pm$1 and relative humidity at 65-70% RH on daily basis to maintain the rearing condition. Cocoon spinning was observed on the 17^{th} day of the experiment at EC1×EJ1 hybrid rearing tray fed with S14 variety mulberry leaves and EC1×EJ2 hybrid rearing tray fed with S30 variety mulberry leaves. The plastic mountages (chandrike) were disinfected and laced on the rearing trays to enable the larvae to be able to suspend themselves while spinning the cocoon (plate 3). Cocoon spun (plate 4) were left for 8days to solidify before harvesting them. The cocoon spun was harvested with small bowl per replicate. The bowls were properly labeled, and necessary parameters were taken and recorded. The experimental design used for the study was laid out in a Randomized Complete Block Design (RCBD) with three replicate. Duncan Multiple Range Test (DMRT) was used to separate means where the means were significant.



Plate 1: Newly emerged silkworm from egg shell



Plate 2: Third instar stage of the larva



Plate 3: Mounted larva on chandrike



Plate 4: Matured cocoon

RESULTS AND DISCUSSION

The following parameters were assessed which include: Larvae weight, percentage of cocoon formed, cocoon weight with flux, deflux cocoon weight, pupae weight and filament length. The result obtained were recorded and analysed as shown in Table 1

Table 1: The mean values of proximate analysis of varieties of mulberry leaves

PARAMETER	S30	S14	S41	S54
Moisture content %	76. 17	75.47	74.17	72.63
Protein %	7.77	7.77	8.57	8.77
Esther extract %	0.93	0.87	0.83	1.10
Ash %	2.80	2.77	2.70	1.26
Crude fibre %	3.60	3.80	3.83	3.77
Carbohydrate %(by difference)	8.77	9.37	9.90	10.93

The result of table 1 above showed that S54 variety of mulberry plant has the highest nutrient values. S30 variety has the highest level of moisture content, this was followed by S14, S41 and S54 respectively. These have implication on the growth of the silkworm also the quantity and quality of the cocoon formed. EC1×EJ1 result: Table 2 shows that T_2 (EC1×EJ1 hybrid silkworm fed with S14 variety) has the maximum mean value of 5.77g as larvae weight, followed by T_4(EC1×EJ1 hybrid silkworm fed with S54 variety) which has the mean value of 4.35g, followed by T_3(EC1×EJ1 hybrid silkworm fed with S41 variety) which has the mean value of 2.87g.T_1(EC1×EJ1 hybrid silkworm fed with S30 variety) has the minimum mean value of 2.83g larvae weight. Result on pupae weight shown that T_2 has the maximum mean value of 10.63g as pupae weight, followed by T_4 which has the mean value of 10.13g. T_1 has the minimum mean value of 8.67g pupae weight.

EC1×EJ2 result: The table shown that T_8 has the highest mean value of 3.92g larvae weight, followed by T_6 (EC1×EJ2 hybrid silkworm fed with S14 variety) which has mean value of 3.88g. T_5 has the least mean value of 3.15g. Result on pupae weight in the table above revealed that that T_6 has the highest mean value of 9.66g pupae weight, followed by T_8 which has mean value of 9.43g. T_5 has the least mean value of 8.20g.

EW1×EW2 result: The result in the table above indicate that T_{12} (EW1×EW2 hybrid silkworm fed with S54 variety) has the maximum mean value of 4.07g larvae weight, followed by T_{10} (EW1×EW2 hybrid silkworm fed with S14 variety) which has the mean value of 3.95g, followed by T_{11} (EW1×EW2 hybrid silkworm fed with S41 variety) which has the mean value of 3.87g.T_9 (EW1×EW1 hybrid silkworm fed with S30 variety) has the minimum mean value of 3.84g larvae weight. Result on pupae weight shown that T_{10} has the maximum mean value of 10.33g as pupae weight, followed by T_{12} which has the mean value of 9.20g. T_9 has the least mean value of 8.57g pupae weight.

Table 2: The separate means using Duncan Multiple Range Test for cocoon quality and quantity parameters for the hybrids

Hybrids Treatment		Percentage of cocoon	Cocoon weight with flux(g)	Deflux cocoon weight (g)	Filament length(m)
EC1×EJ1					
	T_1	49.00d	57.83de	49.67de	375.78cd
	T_2	71.33abc	85.80abc	80.50abc	404.44bcd
	T_3	63.00bcd	68.57bcde	65.07bcde	319.48d
	T_4	76.67ab	90.73ab	86.77ab	462.25bcd
EC1×EJ2					
	T_5	53.00cd	58.75de	51.33de	300.88d
	T_6	86.67a	104.23a	100.00a	459.74bcd
	T_7	63.33bcd	78.70bcd	69.53bcd	410.97bcd
	T_8	48.00d	52.60e	45.57e	620.37ab
EW1×EW2					
	T_9	61.33bcd	52.15e	44.33e	462.50bcd
	T_{10}	45.33d	65.40cde	60.63cde	577.62bc
	T_{11}	50.00d	60.47de	56.70de	424.54bcd
	T_{12}	55.33cd	67.33bcde	63.53bcde	840.30a
DMRT		20.47	24.59	23.36	238.03
GM		60.25	70.21	64.47	471.57
%CV		20.20	20.82	21.54	30.01

The table 2 indicates that means with the same superscript alphabets are not significantly different ($p \geq 0.05$)

EC1×EJ1hybrids: The results on percentage of cocoon formed indicate that T_4 has the highest mean value of 77% followed by $T_{2;}$ T_3 respectively. The least mean value of 49% was observed under T_1 treatment. The result shown on the table revealed that T_4 has the best performance among the treatment. Highest value recorded under T_4 treatment includes: cocoon weight 90.73g; deflux cocoon weight 86.77g; filament length 462.25m. The performance of T_4 is automatically related to the result of mulberry analysis which indicates that S54 variety has the highest level of nutrient. However majority of the nutrient has been used by the silkworm to form cocoon, hence the weight of the pupae observed under T_4 was reduced. T_1 has the least value: 57.85g for cocoon weight with flux; 49.80g for deflux cocoon weight. T_3 has the least mean value of 319.48m filament length. Venugopala Pillai *et al*., (1997) reported that mulberry variety S54 encouraged higher values in larval weight, cocoon weight and cocoon yield.

EC1×EJ2 hybrid: The Table above shown that T_6 has the maximum mean value of 87% cocoon formed, 104.23g for cocoon weight with flux and 100g for deflux cocoon. T_8 has the maximum mean value of 620.36m filament length. While least performance was observed under T_8 at percentage of cocoon, cocoon weight with flux, and deflux cocoon weight with mean value of 48%, 52.60g, 45.57g respectively and T_5 filament length with mean value of 300.88m. Adolkar *et al*., (2007), Giridhar and Reddy (1991), Seidavi (2011) reported that, silkworm rearing performance differed significantly when subjected to same conditions, some of them performed better and poor performance by some races.

EW1EW2 hybrid: The Table above revealed that T_{12} treatment has best performance than other treatment under; percentage of cocoon formed, cocoon weight with flux, deflux cocoon weight and filament length with mean value of 55%, 67.33g, 63.53g and 840.30m respectively. T_9 has the least performance under percentage of cocoon formed, cocoon weight with flux, and deflux cocoon weight with mean value of 42%, 52.15g, and 44.33g respectively, while T_{11} has the least filament length value of 424.54m. Superiority of different mulberry varieties used as food for silkworm larvae greatly affects the economy of sericulture industry (Das and Sikdar, 2000). The results above have shown that too coarse or too tender leaves are less suitable. It was also emphasized that, mulberry leaf quality has direct effect on food consumption ratio, larval growth, digestive coefficient and food absorption (Paul *et al*., 1992), in which influence the performances of S54 variety mulberry leaves as the superior followed by S14 variety for rearing of the silkworm

hybrids. That leaves quality differs among mulberries varieties which in turn is responsible for difference in silkworm rearing performances, also leaves of superior quality enhance the chance for good cocoon crop (Ravikumar, 1998).

CONCLUSION AND RECOMMENDATIONS

The present study has shown that mulberry leaves has positive effect on development of silkworms. Generally, S54 variety proved superior in rearing of hybrid silkworm (EC1×EJ1 hybrid, EC1×EJ2 hybrid, EW1×EW2 hybrid) to other varieties when comparing larvae weight, percentage of cocoon, cocoon weight with flux, deflux cocoon weight, pupae weight, and filament length. This may be because S54 variety gave better economic cocoon characters, protein and carbohydrate content in mulberry leaves, which has a direct bearing on cocoon and silk yield, this was in line with Bongale *et al*., (1997) that leaves quality differs among mulberries varieties which in turn is responsible for difference in silkworm rearing performances, also leaves of superior quality enhance the chance for good cocoon crop (Ravikumar, 1998).

REFERENCES

Adolkar, V., Raina, S. and Kimbu, D. (2007): Evaluation of various mulberry Morus spp. (Moraceae) cultivars for the rearing of the bivoltine hybrid race Shaanshi BV-333 of the silkworm *Bombyx mori* (Lepidoptera: Bombycidae). *International Journal of Tropical Insect Science. 27*(1):6-14.

Ashiru, O.M. (1997): A Seminal on Entrepreneurship development in sericulture, Ekiti State. Pg 1-2.

Bongale, U., Mallikarjunappa, R., Narahari, B., Anantharaman, M. and Dandin, S. (1997): Leaf nutritive quality associated with maturity levels in fourteen important varieties of mulberry (*Morus* spp.). *Sericologia, 37*(1):71-81.

Charles, R. (2006): Florida best fruiting plants*: Native and exotic trees, shrubs and vine.* Sarasota, Florida: pineapple press, Inc. Pg 153

Bongale, U., Mallikarjunappa, R., Narahari, B., Anantharaman, M. and Dandin, S. (1997): Leaf nutritive quality associated with maturity levels in fourteen important varieties of mulberry (*Morus* spp.). *Sericologia, 37*(1):71-81.

Charles, R. (2006): Florida best fruiting plants*: Native and exotic trees, shrubs and vine.* Sarasota, Florida: pineapple press, Inc. Pg 153

Das, B.C. and Sikdar, A.K. (2000): Evaluation of some improved strains of mulberry by eeding experiment. *Indian Journal of Sericulture. 9*(1):26-30.

Datta, R.K. (2002): Mulberry cultivation and utilization in India. In: Sanchez, M.D(ed.) 2002.mulberry for animal production; FAO Animal production and health paper 147. Rome, Pg 45 – 62.

Geetha, P.G. (2007): *Reshme Ugama, Belavanige-lthihaasada Putagainda*. In suvama Reshme Smarama Sanchike 1956-57 to 2006-07(kanada), Department of Sericulture, Government of Karnataka, Bangalore, Pg 1-8.

Giridhar, K. and Reddy, N.(1991): Effective rate of rearing in bivoltine silkworm *Bombyx mori* breeds on different mulberry *Morus*spp. varieties. *Indian Journal Sericulture. 30*(1):88-90.

Paul, D.C., Rao, G.S. and Deb, D.C.(1992): Impact of dietary moisture on nutritional indices and growth of *Bombyx mori*and concomitant larval duration. *Journal* of *Insect Physiology. 38*(3):229-235.

Ravikumar, C. (1998): Western ghat as a bivoltine region prospects, challenges and strategies for its development. *Indian Silk; 26*(9):39-54.

Sanchez, M.D. (2000): Mulberry for animal production; FAO Animal production and health paper 147. Rome, Pg 331.

Seidavi, A. (2011): Evaluation of the genetic potential of six native strains of silkworm *Bombyx mori* L. *African Journal of Agricultural Resources. 6*(20):4816-4823.

Shankar, M.A., Shivashankar, K. and Devaiah, M.(1994): Effect of feeding mulberry leaves deficient in secondary nutrients on larval growth, development, cocoon weight and silk quality. *Sericologia* 34 (3):511-518

Venugopala, P. and Krishnaswami, S. (1997): Adaptability of silkworm *Bombyx mori* (L.) to tropical conditions III. Studies on the effect of high temperature during later developmental stages of silkworm. *Indian Journal of Sericulture*, 26 (2):63 – 71.

Wang, Z. (1987): Sericulture in ancient China's Technology and Science. Compiled by the Institution of the History of Natural Science Chinese*; Academy of science*. Beijing, foreign language press. 12(2):1-8. ISBN 0-8351-1001

Early Growth Study of *Holarrhena floribunda* (G. Don.) Dur. Schinz using Different Organic Fertilizers

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ABSTRACT

Early growth of Holarrhena floribunda was examined in this study. The seeds of Holarrhena floribunda were broadcast into the germination box filled with sterilized river sand and watered regularly. The seedlings that emerged were randomly transplanted into polythene pots of different sowing media as top soil, topsoil with poultry droppings, and top soil with cow dung. Growth parameters taken weekly were plant height, leaf production and stem girth. The result showed that seedlings sown in topsoil with poultry manure produced the best growth in plant height, stem girth and leaf production with 12.33 cm, 0.42 mm and 12.54 respectively and treatments with no application of organic manure had the least performance with 10.25 cm, 0.35 mm and 11.60 respectively. However, there were significant differences among the treatments and it can be concluded that Holarrhena floribunda thrive well when raised in top soil enhanced with poultry manure as shown in the findings of this study and more work should be carried out on the species to sustain its dwindling population in the wild due to over exploitation for medicinal uses.

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Keywords: Forests, *Holarrhena floribunda*, Organic manure, Poultry droppings, cow dung, early growth

INTRODUCTION

Forests are invaluable and indispensable natural resources, which satisfy a wide range of human needs varying from tangible to intangible benefits. They provide a range of economic, social and environmental goods and services. They have impact on the well being of resource-poor farmers, local and national economies and global environmental health. However, the goods and services offered by the forests can only be sustained if they are maintained above a given threshold (Boffa *et al.*, 1999). But unfortunately, the reality of the situation is that these forests have been disappearing at alarming rates mostly due to human activities (Adeyoju, 2001). For many decades now, African forests have witnessed devastating depletion, indiscriminate felling and in many cases have been affected by genetic degradation. This degradation threatens biodiversity, hydrology, soils, plant and animal life as well as stability and quality of life especially for the rural communities who depend on the vegetation for a variety of products and services. As deforestation progresses the physiognomy changes from forests to wooded savanna to grass savanna and the savanna into semi-arid vegetation.

Nigeria's forest lands have majorly been converted to non-forest uses including permanent agriculture, shifting cultivation, human settlement such as building of houses, mining, constructing dams, road construction (Burkill, 1985). Today, there is a growing concern throughout the world about the uncontrolled depletion of the earth's natural resources especially those affecting plant diversity of tropical forests (Jayachandra *et al*., 2009). One of several reasons is because plant resources continue to play a central role in the livelihood of the rural poor in Africa. Research studies have mostly centered on timber and fruit trees species such as *Tectona grandis* (Teak), *Gmelina arborea (*Gmelina), *Persea Americana* (pear) etc. whose utilization is recognized among the foresters, this is because of less preferential treatment are given to non-timber species, for example *Holarrhena floribunda* which is not only use for fuel wood but also for medicinal purposes is managed by traditional healers and rural dwellers (Akah, 1997).

Holarrhena floribunda commonly known as 'false rubber tree' belongs to the family of *Apocynaceae*. It is a small to medium size tree (10 to 15m) depending on the ecological zones (Tamboura *et al*., 2005). *Holarrhena floribunda* occurs in open localities, relic deciduous, closed woodland forest, sometimes fringing and riverine forest and in northern guinea savanna on clay, sand, lateritic soils or rocky outcrops, from sea-level up to 1000 m altitude. The generic epithet *Holarrhena* is derived from Greek meaning complete

male, whereas the specific epithet refers to its prolific flowering trait. (Okafor, 1993). Most of the useful non timber forest species such as *Holarrhena floribunda* are destroyed continuously in the forest (Ikumoguyi, 1980) especially during timber extraction.

Medicinal plants are said to form the largest grouping of plant with about 30,000 species used for medicine worldwide and nearly a third of them are trees (Schmelzer, 2008). Several studies have been conducted on the medicinal and ethno-botanical studies of *Holarrhena floribunda,* the stem, bark and leaves are used for treating various ailments such as malaria, dysentery, fever, female sterility, skin infection, venereal diseases and snake bite (Badmus, *et al*., 2010, Fortie, *et al*., 2006, Neuwinger, 2000, Tamboura et al., 1998) whereas little has be done in area of research into propagation and early growth of *H floribunda.* It is important to carry out researches on the growth studies of *Holarrhena floribunda* as a typical example of non-timber species so as to alleviate to a large extent the imminent loss currently faced by this species as a result of utilization threat and lack of management concern. This study therefore looked into the effect different soil media had on the growth of this species with the aim of determining the best for its optimal growth at the nursery stage.

MATERIALS AND METHODS

Study Area

The experiment was carried out in the Federal College of Forestry, Jericho, Ibadan which lies within $7^0$23'15"N; $3^0$51'00"E and $7^0$24'00"N; $3^0$52'15"E of the Greenwich Meridian. The rainfall pattern is bimodal, with peaks around June to July and September to October. Mean annual rainfall is about 420.06 mm in 109 days with mean maximum and minimum temperatures of about 34^{o}C and 24^{o}C respectively. Mean relative humidity ranges from about 82% between June and September, to approximately 60% between December and February. Topography is undulating with underlying ferruginous sandy loam soils on crystalline rocks of undifferentiated pre-Cambian basement complex (sources: Ariwodo, *et al*., 2012 and FRIN Met. service, Ibadan, 2014).

Experimental Procedure

Four weeks old uniformly growing seedlings of *Holarrhena floribunda* were transplanted into polythene pots filled with different soil media. The media were prepared such that 5kg of top soil was filled into the polythene pot of size 21 x 6 cm and the following treatments were established:
T_1 = Control (5kg of Top soil)
T_2 = 5g of Top soil with 5g of poultry manure
T_3 = 5g of Top soil with 10g of poultry manure
T_4 = 5g of top soil with 15g of poultry manure
T_5 = 5g of top soil with 5g of cow dung
T_6 = 5g of top soil with 10g of cow dung
T_7 = 5g of top soil with 15g of cow dung
The experiment was set up in Completely Randomized Design (CRD) and replicated five times.

The parameters assessed were:

Seedling height: The height of the seedlings was measured with meter rule from the collar tip to the terminal bud.

Leaf production**:** The total number of the leaves were counted and recorded.

Collar diameter**:** This was measured by the use of vernier caliper at the base of the seedlings.

The seedlings were maintained by watering regularly and weeded when necessary.

RESULTS

Height

The results obtained from this study (table 1) showed that the seedlings of *Holarrhena floribunda* treated with 15kg of poultry manure (T_4) had the best performance in height with mean value of 12.33 cm. Seedlings treated with 10g of poultry manure (T_3) performed better with mean of 11.31 cm while seedlings raised without organic manure (T_1) had the least performance with an average mean of 10.25cm. There was a significant difference in the mean values of the various treatments for height.

Stem diameter

Result for stem diameter revealed that the treatments also varied significantly from one another with T_4 having the best outcome with an average mean of 0.42 mm followed by T_7 with an average mean of 0.40 mm while seedlings raised without fertilizer application T_1 performed least with mean value of 0.34 mm.

Leaf count

Results also indicated that T_4 had the best performance in leaf production with an average mean of 13.54 followed by T_3 with 11.88 while T_1 had the least performance in leaf production with an average mean of 11.60. There was a significant variation in the mean values of the treatments.

Table 1: Mean effect of organic fertilizers on height, collar diameter and leaf production of *Holarrhena floribunda.*

Treatment	Height	Collar diameter	Leaf production
T_1	10.25_b	0.34_{bc}	11.60_d
T_2	10.57_b	0.38_{bc}	12.04_{bcd}
T_3	11.31_{ab}	0.36_c	11.88_{cd}
T_4	12.33_a	0.42_a	13.54_a
T_5	10.66_b	0.37_c	12.50_{abcd}
T_6	10.94_b	0.36_c	13.26_{ab}
T_7	10.99_b	0.40_{ab}	13.12_{abc}

DISCUSSION

Soil fertility improves appreciably when enhanced with appropriate quantity of organic manure such as poultry manure, cowpat, pig dung, horse dung and leads to increased productivity. Organic manure contains macro elements as well as many other mineral elements needed by the plants for growth and development. *Holarrhena floribunda* responded well to the application of organic manure and in particular poultry manure in all the parameters measured. Poultry manure has been reported as an excellent source of nutrients which can be incorporated into most fertilizer programs (Telkamp, 2015). Significant responses recorded showed that poultry manure is best applied at 15g for optimal yield. This result agrees with the findings of Ojo *et al*. (2009) in an experiment on response of *Adansonia digitata L*. to organic and inorganic fertilizers found that poultry manure produced the highest mean height and leaf production while NPK 15:15:15 produced highest mean leaf area and stem diameter. Ihejirika *et al*. (2003) also reported the use of poultry manure as organic soil amendments. This is in line with the observation of Donalue *et al.* (1990) that nitrogen, phosphorus and potassium are essential for plant growth particularly at the early stage. The result of nutrient analysis (table 2) shows the quantity of the essential elements present in the manure used. It can be deduced that *Holarrhena floribunda* was able to maximally utilize the nutrient present in the poultry manure and especially the nitrogen which may be responsible for its rapid growth and this is in line with Aliyu, (2000) who noted that plant generally have higher requirement for nitrogen than for the other major elements.

Table 2: Analysis of poultry manure and cow dung used for the experiment

	N%	$PasPO_4$ (mg/100g)	K^+ (mg/100g)
Poultry manure	0.93	25	75
Cow dung	0.90	75	25
Top soil	0.22	65	30

CONCLUSION AND RECOMMENDATION

Despite its multipurpose uses, little effort had been made on regeneration of *Holarrhena floribunda*, a non-timber species given its diminishing population in the natural stands. Raising this species with poultry manure showed a promising potential of a maximum yield at the nursery stage. When this species is raised, it will lessen pressure on timber species for firewood and traditional medicine. It is therefore, recommended that poultry manure is cost effective when raising *Holarrhena floribunda* seedlings in the nursery.

REFERENCES

Adeyoju, S. K. 2001. Forestry for National Development: A critique of the Nigeria situation. Proceedings of the 27th Annual Conference of the Forestry Association of Nigeria Abuja FCT (eds. Popola, L. and Abu, J.E.), pp55-68.

Akah I. A. 1997: The useful plants of West Tropical Africa published by Royal Botanic Gardens Kew pg 5-8.

Aliyu, I. 2000. The Effect of Organic and Mineral Fertilizer on Growth Yield and Composition of pepper (Capsicum annum L.) Bio. Agric. Hort. 18:29-38.

Ariwaodo, J. O., Chukwuma, E. C. and Adeniji, K. A. 2012. Some Medicinal Plant Species of Asamagbe Stream Bank Vegetation, Forestry Research Institute of Nigeria, Ibadan. Ethnobotany Research & Applications 10:541-549 (2012). Available at www.ethnobotanyjournal.org/vol10/ i1547-3465-10-541.pdf

Badmus J. A., Odunola, O. A., Obuotor, E. M. and Oyedapo, O. 2010. Phytochemicals and *in vitro* antioxidant potentials of defatted methanolic extract of Holarrhena floribunda leaves. *Afr. J. Biotechnol* 9(3):340-346.

Boffa, J. M., Taonda, S. J. B., Dickey, J. E and Knudsen, D. M. 1999. Field-scale influence of Karite (*Vitellaria paradoxa*) on white sorghum production in the Sudan zone in Burkina Faso, West Africa. Paper submitted to *Agroforestry Systems*.

Burkill, H. M. 1985. The useful plants of west Tropical Africa.2nd Edition.Volume1 families A-D.Royal Botanic gardens,kew Richmond united kingdom.960pp.

Donalue, R. L., Midler, R. W and Shiekluna, J. C. 1990. Soils. *An introduction to soils and plant growth.* Prentice Hall of India, Private Ltd. New Delhi, 667p.

Fortie J, Bohle S, Leimanis D, Mara L, Georges E, Rukunga G, Nkengffack A E (2006). Lupeol long-chain Fatty Acid Esters with antimalarial activity from *Hollarhena floribunda. J. Nat. Prod*. 69:62-67.

Ihejirika, G. O., Onwermadu, E. U., and Duruigbo, I. C. 2003. Effect of organic manures and plant densities on severity of leafspot disease and yield of groundnut in an ultisol. Proceedings of the Agricultural Society of Nigeria 37th Conference, Calabar.

Ikumoguyi, B. A. 1980. Illegal felling activities and their harmful effect on Nigeria environment; paper presented at the 10th Annual Conference held at Sokoto State 10p.

Jayachandra P. R., John, B. S. and Balakrishnan, V. 2009. Regeneration of plants through somatic embryogenesis in *Emilia zeylanica* C.B. Clarke a potential medicinal herb. *Bot. Res. Int*. 2(1):36-41.

Neuwinger, H.D., 2000. African traditional medicine: A dictionary of plant use and applications.

Ojo, M. O., Akoun, J., Aderounmu, A. F., Adeniji, R. A. and Adekola, P. J. 2009. Response of *Adansonia digitata L*. to organic and inorganic fertilizers. Proceedings of the Annual Conference of IRDI Science and Technology Forum. May 5-8, 2009, Conference Centre , University of Lagos, Nigeria.

Okafor, J. C. 1993. Lost crops of Nigeria: An overview. In: Proceedings of the seminar on lost crops of Nigeria. pp. 2-32.

Schmelzer, G. 2008. Documentary of medicinal plants in Tropical Africa. In: Plant resources of Tropical Africa (PROTA) Num 7: January-June 2008 p.8.

Tamboura H. H., Bauyala, B., Lompo. M., Guissou, I. P., Sawadogo, L. 2005. Ecological distribution, morphological characteristics and acutetoxicity of aqueous extracts of *Hollarhena floribunda* (G. Don) Durandan Schinz, *Leptadenia hatata* (Pers.) Decne and *Cassia sieberiana* DC used by veterinary healers in Burkina Fasso. Afr.Trad. CAM (2005) 2(1):13-24.

Telkamp, M. The Straight Poop on Using Chicken Manure as Fertilizer Retrieved 16th February 2015.

Temu, A. B. 2002. African forestry and chanllenges of sustainable livelihood". Proceeding of the 28th Annual Conference of the Forestry Association of Nigeria in Akure, Ondo State, Nigeria, from 4th – 8thNov. pp.1-10.

UNDP, 2002. World Energy Assessment. United Nations Development Programme, United Nation Department of Economics and Social Affairs and World Energy Council, New York UNDP.

Above-Ground Bole Carbon Stock Assessment using Forest Inventory Data for the Secondary Forest Ecosystem in International Institute of Tropical Agriculture, Ibadan, Nigeria

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ABSTRACT

Vegetation biomass is an important ecological variable for understanding the changes of climate and carbon sequestration in a forest. Estimating above-ground bole biomass using inventory data is the most important step in measuring the carbon stock and fluxes. Therefore the above-ground bole carbon stock assessment using forest inventory data for the secondary forest ecosystem in International Institute of Tropical Agriculture (IITA) was necessary. The study was carried out in secondary forest with systematically laid one hundred and forty sample plots of 50m x 50m (0.25ha). The plots were primarily established with 10% sampling intensity. All trees in each plot were measured for tree height, and tree diameter at breast height (DBH). Sixty wood core samples were randomly collected from dominant trees at breast height using an increment borer for wood density. Wood density and tree volume were used in the computation of above-ground bole carbon stock. Data were analysed using descriptive and inferential statistics. A total of 10,055 trees comprising of 121 tree species and 30 different families were recorded. Wood density varied amongst species ranging from 0.23g/cm^3 to 0.89g/cm^3. Average wood density values were 1299.18, 567.26, and 933.52, respectively, while the average DBH values were 42464.57, 17879.24, and 37193.45, respectively, and the average total tree height values were 26854.20, 10078.01, and 23314.24, respectively. Total above-ground biomass and carbon stock were 3381754.16g/ha and 1690877.08g/ha. There was a correlation between above-ground biomass with DBH, H, volume and wood density. Above-ground bole carbon stock estimation in IITA provides baseline information for sustainable management of the secondary forest ecosystem for optimal carbon sequestration.

Keywords: IITA ecosystem, forest inventory, tree species, wood density, carbon stock

INTRODUCTION

Tropical forest lands are a natural forest type that is an important source of biodiversity, food, and carbon storage (Food and Agriculture Organization, 2011). Tropical forests comprise the largest proportion of the world's forests at 44% (FAO, 2011); Tropical forests also contain one of the largest carbon pools and have a significant function in the global carbon cycle (FAO, 2011). Forests store carbon contain approximately 80% of the total above-ground organic carbon and 40% of the total below-ground organic carbon worldwide (FAO, 2011). Deforestation and forest degradation contribute between 15% - 20% of global carbon emissions, and most of this contribution comes from tropical regions (FAO, 2011). Approximately 60% of the carbon sequestered by forests is released back into the atmosphere via deforestation (FAO, 2011). The amount of carbon sequestered by a forest can be inferred from its biomass accumulation because approximately 50% of forest dry biomass is carbon (Brown, 1997). The majority of biomass assessments are performed for the above-ground biomass (AGB) of trees because this biomass generally represents the greatest fraction of the total living biomass in a forest and does not pose significant logistical problems during field measurements (Intergovernmental Panel on Climate Change, 2007).

There are uncertainties with regard to the accurate estimation of biomass in natural forest ecosystems (FAO, 2009). These uncertainties are responsible for overestimation or underestimation of biomass or carbon, typically attributed to the complexity of forest ecosystems (FAO, 2009). Therefore vegetation biomass is an important ecological variable for understanding the changes of climate and carbon sequestration in a forest (FAO, 2009). It is generally agreed that preservation of forest areas can contribute strongly to the mitigation of global climate change (United Nations Framework Convention on Climate Change, 2008). Therefore, there is need for estimating above-ground bole biomass in measuring carbon stocks and fluxes secondary forest ecosystem in IITA in order to determine the contribution of the forests in terms of carbon stock.

METHODOLOGY

The Study Area

The core area of International Institute of Tropical Agriculture (IITA) Forest Reserve lies at 07^{o} 30' N and 03^{o} 55' E and about 227m altitude in the city of Ibadan. Ibadan lies in the transition zone between equatorial rainforest to the south and savanna to the north (latitude 7.38778, longitude 3.89639 in decimal degrees).

Brief History of the Secondary Forest Ecosystem

When the land was acquired by IITA in 1965, the area was secondary forest interspersed with farmland, bush and 26 villages whose occupants were re-settled in the nearby purpose-built villages of Sasha. After construction of campus facilities and the allocation of farmland for crop research, about a third of the site - some 350 ha - was designated a nature reserve. In 1987 campus residents embarked on a voluntary project to create pathways through the forest. (Hall and Okali, 1976, 1979)

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Today this core area constitutes the IITA forest reserve which is strictly protected as one of the few remaining forest fragments in southwest Nigeria. Bordering on the forest reserve are some 50 ha of highly degraded land formerly used for experimental cropping, which is at the early stage of regeneration known as bush. There is also a belt of further secondary forest which in1975 was marked into 50 plots 25m x 25m in size for a vegetation report on the two watersheds at IITA. In addition, there are various smaller wooded areas, an arboretum which was established in 1979, and nine lakes, the largest of which is a reservoir 2.6 km long, formed in 1970 by constructing a dam on the Awba River. These bush, secondary forest and wetland areas, together with farmland and gardens, provide a great diversity of habitats for wild plants and animals. After more than 50 years of protection, and with continuing loss of forest in southwest Nigeria, the IITA campus is increasingly important as a refuge for many species that were once widespread (Hall and Okali, 1976, 1979).

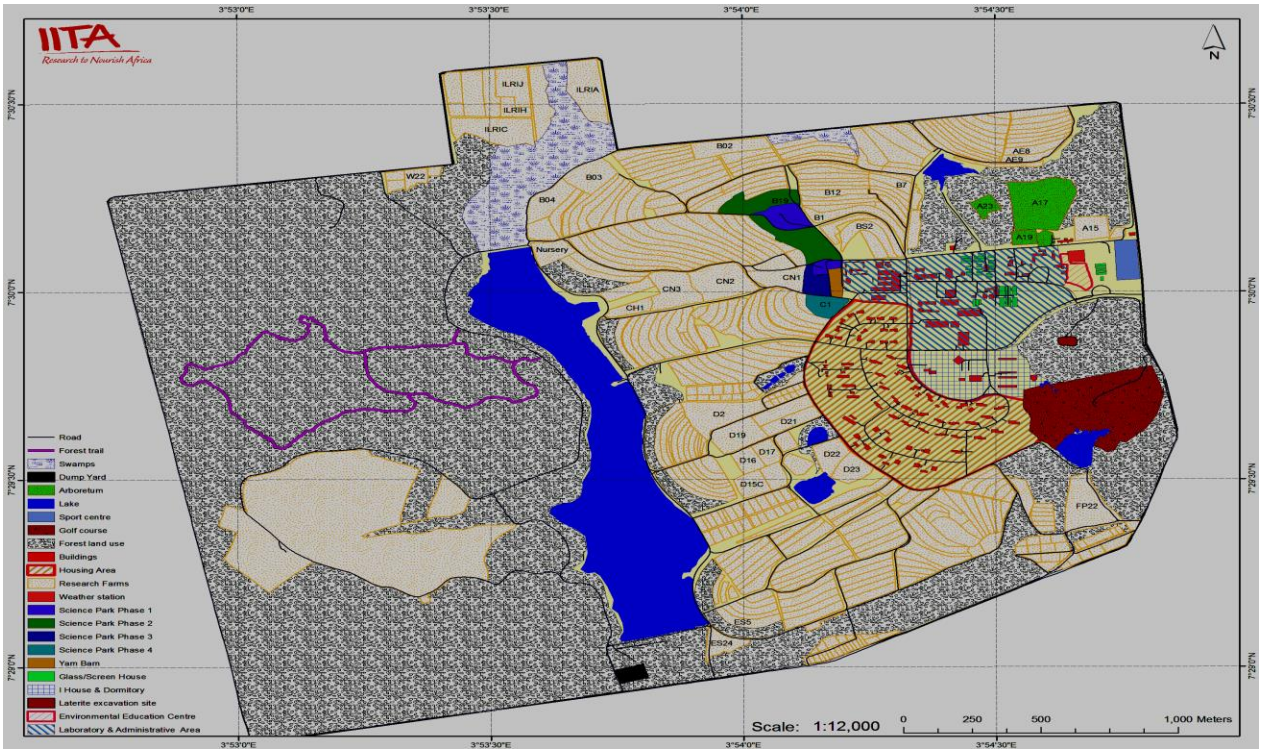


Figure 1: Map of International Institute of Tropical Agriculture, Ibadan

Sampling Techniques and Laying of Sample Plots

Reconnaissance survey of the study site was carried out. Systematic sampling technique was used to select sample plots of 50m x 50m (0.25ha) in size. The sample plots were primarily established with 10% sampling intensity. One hundred and forty (140) sampling plots were randomly laid in the forest reserve , trees in all of the plots with a diameter at breast height (DBH) equal or greater than 10

cm at 1.3 m above the surface level was measured (Lu, 2006). The trees within a sample plot were measured for diameter at breast height (DBH) and total tree height (H). A botanist and local people were engaged for the identification of botanical names and local names of trees respectively. The number of sample plots and the distance between plots were determined by the formula (Munishi, 2005).

$$N = \frac{T_A \, X \, S_i}{P_S \, X \, 100} \quad \ldots\ldots 1$$

Where N = number of sample plots, T_A = Total area of the forest, P_S = Plot size and
S_i = Sampling intensity, while the distance between plots was determined by the formula (Munishi, 2005):

$$D = \sqrt{\left(\frac{Af \, X \, 10000}{N}\right)} \quad \ldots\ldots 2$$

Where D = inter plots distance (m), Af = Area of the forest (ha) and N = number of plots.

Basal Area Estimation

The diameter at breast height (DBH) was used to compute basal area using the formula (Husch *et al.*, 1972):

$$BA = \frac{\pi d^2}{4} \quad \ldots\ldots 3$$

Where BA = Basal area (m^2), π = 3.143, d = Diameter (cm)

Volume Estimation

Above ground biomass (AGB) was computed as a product of total tree volume. The volume of trees was estimated using Huber's formula (Husch *et al.*, 1972):

V = H x BA… ……………………………………………………………………………4

Where: V = Volume of the tree (m^3), H = Tree total height (m)

Estimation of Wood Density

Wood density is defined as the ratio of the oven-dry mass of a wood sample divided by the mass of water displaced by its green volume (wood specific gravity, or WSG) (Chave, 2005). Sixty wood core samples were randomly collected from dominant tree species using a device called an increment borer. An estimate of wood density requires the collection of cores of wood from randomly selected trees. The core samples were oven-dried to a constant weight at 105^o C (FAO, 1997):

$$V = \frac{\pi}{4} D^2 L \quad \ldots\ldots 5 \text{ (Chave, 2005)}$$

Therefore,

$$\rho = \frac{M}{V} \quad \ldots\ldots 6 \text{ (Chave, 2005)}$$

Where,

ρ = wood density, V = volume of the core sample, M = oven-dry mass of core sample, L = total length of the core sample, D = diameter of core sample, π = pi (3.142).

Above-Ground Biomass (AGB) Estimation

Above-ground biomass of the various tree species were carried out using tree volume and wood density values. In general, AGB was estimated as:

$$AGB = Volume \, X \, WD + \varepsilon \quad \ldots\ldots 7$$

Where, WD and Ɛ, represent wood density and error respectively (Wang, *et al.* 2011).

Estimation of bole carbon sock within a sample plot for the study area

The mean plot of AGB for each species in the study area was calculated and then be multiplied by 0.25 to obtain the AGB per hectare. Half of the value gave the bole carbon stock per hectare for the location (Aghimien *et al.*, 2015).

RESULTS AND DISCUSSION

Vegetation Structure and Forest Composition

A total of one hundred and twenty one (121) tree species were found in the sample plots laid in the study site from 10,055 individual trees. The dominant species in the study site included *Albizia zygia* (236), *Antiaris Africana* (927), *Blighia sapida* (1400), *Celtis Africana (237), Ficus exasperata* (823), *Funtumia elastica* (2215), *Gambeya albidum* (715), *Holarrhena floribunda* (146), *Lecanodiscus cupanioides (351), Milicia excelsa* (36), *Millettia thonningii* (86), *Morus mesozygia* (66), *Nauclea diderrichii* (107), respectively. Overall tree species recorded belonged to thirty (30) different families (table 1). Some dominant species in this study were similar to the previous studies carried out by Aghimien *et al.,* (2015) which included *Blighia sapida* (148), *Funtumia elastic*(139), *Newbouldia leavis* (193), *Ficus exasperata* (78), respectively.

The wood densities of wood are indirect indicators of carbon storage capacity of trees. Standard wood density varied amongst species ranging from 0.22g/cm^3 to 0.86g/cm^3, with about 90.00% of wood density falling between 0.23g/cm^3 and 0.89g/cm^3 (Table 2). The wood density values for species estimated in this study were similar with density values obtained for the same species in previous studies carried out by Reyes *et al.,* (1992) which included 1,280 entries from tropical America (40 percent), tropical Asia (36 percent), and tropical Africa (24 percent); Zanne *et al.,* (2009) which included 16,469 entries from tropical America, tropical Asia, and tropical Africa. Wood density of core samples taken at breast height are not assumed to represent the wood density of the whole tree but are only used as statistical predictors of the above-ground biomass of tree and have been shown to be significantly correlated with the above-ground biomass of trees (Chave *et al.,* 2006).

Table 1: Distribution of Trees in the IITA Secondary Forest Ecosystem According to Family

	Family	No. of Family	No. of Observation	% of the Total
1	Anacardiaceae	2 (1.65%)	675	6.71
2	Apocaceae	3(2.48%)	2362	23.49
3	Bombacaceae	1(0.83%)	6	0.06
4	Bignoniaceae	2(1.65%)	1013	10.07
5	Boraginaceae	1(0.83%)	1	0.01
6	Chrysobalanaceae	1(0.83%)	4	0.04
7	Combreteceae	2(1.65%)	2	0.02
8	Caesalpinaceae	3(2.48%)	4	0.04
9	Ebenaceae	1(0.83%)	15	0.15
10	Euphorbiaceae	1(0.83%)	7	0.07
11	Fabaceae	20(16.53%)	71	0.71
12	Helicteraceae	1(0.83%)	34	0.34
13	Irvingiaceae	2(1.65%)	12	0.12
14	Fabaceae -Caes	9(7.44%)	40	0.40
15	Fabaceae -Mim	17(14.05%)	315	3.13
16	Fabaceae -Pap	25(20.66%)	188	1.87
17	Leycithidaceae	1(0.83%)	25	0.25
18	Malvaceae-Tiliaceae	3(2.48%)	11	0.11
19	Moraceae	8(6.61%)	1888	18.78
20	Myristicaceae	1(0.83%)	194	1.93
21	Meliaceae	1(0.83%)	297	2.95
22	Moringaceae	1(0.83%)	2	0.02
23	Proteaceae	1(0.83%)	4	0.04
24	Rutaceae	2(1.65%)	2	0.02
25	Rubiaceae	2(1.65%)	112	1.11
26	Sapindaceae	2(1.65%)	1751	17.41
27	Sapotaceae	3(2.48%)	727	7.23
28	Sterculiaceae	2(1.65%)	5	0.05
29	Ulmaceae	2(1.65%)	274	2.73
30	Verbenaceae	1(0.83%)	14	0.14
	TOTAL	**121(100%)**	**10,055**	**100.00**

Range and average wood density of 0.66 g/cm^3 and 0.57 g/cm^3 obtained in this study was different from to the values reported in previous studies of forests in Africa due to the complex stand structures and species composition in IITA. Reyes *et al.,* (1992) reported

a range of 0.20 g/cm^3 to 0.93 g/cm^3 with an average of 0.50 g/cm^3 in Cameroon and Gabon. The average dominant species of wood densities of the sample site were 1299.18, 567.26, 933.52, 1018.97, and 508.06, respectively, while the average dominant DBH of the sample site were 42464.57, 17879.24, 37193.45, 31900.89, and 14818.05, respectively, and the average dominant tree total height values of the sample site were 26854.20, 10078.01, 23314.24, 19557.53, and 8391.45, respectively. Apocaceae had the highest average density value for species at family level, followed by Sapindaceae while Rutaceae had the lowest density value. Apocaceae had the highest average diameter at breast height value for species, followed by Moraceae, while Boraginaceae had the lowest DBH value species. Apocaceae had the highest average total height value for species, followed by Moraceae while Boraginaceae had the lowest total height value for species. In this study, the diameter at breast height, wood density and height values of each individual species in the plots were used to estimate the above-ground biomass.

Table 2: Descriptive Results of Diameter at Breast Height-DBH, Total Height-H and Wood Density-WD

	DBH (cm)	H (m)	WD (g/cm^3)
Mean	19.17	11.70	0.57
Standard Error	0.08	0.04	0.00
Standard Deviation	7.72	4.10	0.09
Range	67.73	38.60	0.66
Minimum	10.76	4.70	0.23
Maximum	74.50	39.30	0.89
Count	10,055	10,055	10,055

Table 3: Average total height (H), diameter at breast height (DBH), and wood density (WD) values of trees

Family	Avg. H (m)	Avg. DBH (cm)	Avg. Density (g/m^3)
Anacardiaceae	8212.40	14468.98	364.05
Apocaceae	26854.20	42464.57	1299.18
Bombacaceae	35.20	83.32	0.92
Bignoniaceae	10078.01	17879.24	567.26
Boraginaceae	7.20	13.54	0.78
Chrysobalanaceae	41.00	70.27	3.56
Combreteceae	23.60	31.36	1.09
Caesalpinaceae	48.80	68.76	2.46
Ebenaceae	221.80	496.87	10.50
Euphorbiaceae	65.20	100.54	2.73
Fabaceae	914.50	1390.16	45.34
Helicteraceae	741.80	1288.56	10.88
Irvingiaceae	180.00	225.07	8.00
Leg-Caes	481.00	658.38	30.21
Leg-Mim	3984.10	6261.80	181.41
Leg-Pap	3140.70	5753.70	113.71
Leycithidaceae	258.50	373.98	10.25
Malvaceae-Tiliaceae	143.40	162.90	5.96
Moraceae	23314.24	37193.45	933.52
Myristicaceae	2564.60	4793.16	116.40
Meliaceae	3207.90	4831.16	178.20
Moringaceae	20.00	27.04	1.20
Proteaceae	69.80	109.95	2.32

Rutaceae	25.00	34.21	0.66
Rubiaceae	1020.80	1715.70	70.56
Sapindaceae	19557.53	31900.89	1018.97
Sapotaceae	8391.45	14818.05	508.06
Sterculiaceae	60.90	107.90	4.16
Ulmaceae	3720.60	5063.48	205.87
Verbenaceae	236.10	285.12	5.74

Table 4: Average basal area, volume (Vol.), and above-ground biomass per plot of the trees

Family	Avg. BA (m^2)	Avg. Vol. (m^3)	Avg. Plot AGB (g)
Anacardiaceae	266726.85	1742009.81	940208.45
Apocaceae	641571.37	3863055.37	2124773.66
Bombacaceae	1442.28	5739.84	1320.16
Bignoniaceae	264862.33	1353382.71	757845.17
Boraginaceae	143.96	518.27	404.25
Chrysobalanaceae	1036.79	5210.03	4636.93
Combreteceae	393.05	2349.72	1291.43
Caesalpinaceae	1033.85	7639.04	5073.28
Ebenaceae	12989.01	96132.57	67292.80
Euphorbiaceae	1157.29	5420.47	2113.98
Fabaceae	24093.69	182283.25	111715.32
Helicteraceae	39054.67	428746.74	137198.96
Irvingiaceae	3575.60	29974.79	18248.56
Leg-Caes	9314.70	61044.98	46875.90
Leg-Mim	124646.34	952913.89	567026.55
Leg-Pap	176063.33	1727289.68	1000564.63
Leycithidaceae	4535.33	24893.86	10206.48
Malvaceae-Tiliaceae	1918.22	12226.89	6879.36
Moraceae	757417.56	6687433.94	3527339.70
Myristicaceae	96289.76	636284.07	381770.44
Meliaceae	65440.48	349720.73	209832.44
Moringaceae	288.51	1446.47	867.88
Proteaceae	3215.88	30956.46	17954.75
Rutaceae	481.32	3247.48	1071.67
Rubiaceae	22032.25	105863.45	66693.98
Sapindaceae	492436.92	2864039.06	1673906.53
Sapotaceae	275111.30	1986713.41	1389658.60
Sterculiaceae	2034.08	15354.12	13346.56
Ulmaceae	78278.81	561964.78	421949.72
Verbenaceae	5010.08	46215.84	18948.50

Table 5: Above-ground biomass (AGB) and bole carbon stock per hectare of the trees

Family	N	AGB per ha	Bole carbon stock per ha
Anacardiaceae	2	235052.11	117526.06
Apocaceae	3	531193.41	265596.71
Bombacaceae	1	330.04	165.02
Bignoniaceae	2	189461.29	94730.65
Boraginaceae	1	101.06	50.53
Chrysobalanaceae	1	1159.23	579.62
Combreteceae	2	322.86	161.43
Caesalpinaceae	3	1268.32	634.16
Ebenaceae	1	16823.20	8411.60
Euphorbiaceae	1	528.50	264.25
Fabaceae	20	27928.83	13964.42
Helicteraceae	1	34299.74	17149.87
Irvingiaceae	2	4562.14	2281.07
Leg-Caes	9	11718.97	5859.49
Leg-Mim	17	141756.64	70878.32
Leg-Pap	25	250141.16	125070.58
Leycithidaceae	1	2551.62	1275.81
Malvaceae-Tiliaceae	3	1719.84	859.92
Moraceae	8	881834.92	440917.46
Myristicaceae	1	95442.61	47721.31
Meliaceae	1	52458.11	26229.05
Moringaceae	1	216.97	108.49
Proteaceae	1	4488.69	2244.34
Rutaceae	2	267.92	133.96
Rubiaceae	2	16673.49	8336.75
Sapindaceae	2	418476.63	209238.32
Sapotaceae	3	347414.65	173707.32
Sterculiaceae	2	3336.64	1668.32
Ulmaceae	2	105487.43	52743.72
Verbenaceae	1	4737.12	2368.56

Table 6: Pearson Correlation Coefficients

	H(m)	DBH (cm)	D(g/m^3)	VOL.(m^3)	AGB per ha
H(m)	1				
DBH(cm)	1.00	1			
D(g/m^3)	0.99	0.99	1		
VOL.(m^3)	0.92	0.92	0.87	1	
AGB per ha	0.93	0.93	0.89	1.00	1

Total Above-Ground Biomass Analysis of the Land-Cover from Field Data

The highest average above-ground biomass per plot were found in Moraceae with a value of 3527339.70, followed by Apocaceae with an average value of 2124773.66, while Boraginaceae had the lowest average above-ground biomass per plot for trees with a value of 404.25. The results also showed that the highest average volume was found in Moraceae with a value of 6687433.94, followed by Apocaceae with an average value of 3863055.37, while Boraginaceae had the lowest average volume of 518.27. The highest average basal area value were found in Moraceae (757417.56), followed by Apocaceae with a value of 641571.37, while Boraginaceae had the lowest average basal area value of 143.96 for all of the trees at family level (Table 4).

The highest carbon content per hectare were found in Moraceae with a value of 440917.46, followed by Apocaceae with a value of 265596.71, while Boraginaceae had the lowest carbon content per hectare with a value of 50.53. The results also showed that the highest above-ground biomass per hectare were found in Moraceae with a value of 881834.92, followed by Apocaceae with a value of 531193.41, while Boraginaceae had the lowest value of above-ground biomass per hectare of 101.06. The total above-ground biomass and bole carbon stock per hectare for all the trees were calculated to be 3381754.16 and 1690877.08 (Table 5). Aghimien, *et al.*, (2015) reported that the above-ground tree biomass at whole stand level accounted for 838036.15g/ha through allometric equations, while above-ground tree biomass and carbon per hectare accounted for 736560.83 g/ha and 368280.40 g/ha through standard method due to variation in the size of sample plots and a wider coverage in International Institute of Tropical Agriculture.

A very strong relationship was observed between the above-ground biomass per hectare and trees volume with correlation value of 1.00, followed by trees height and diameter at breast height with a value of 1.00. However, above-ground biomass per hectare had the lowest correlation value of 0.89 with wood density (Table 6). This implies that all the indicators are very good predictors for above-ground bole biomass.

CONCLUSION

Among the multiple methods for estimating above-ground carbon stock, the field data method is reliable and widely applicable. The critical components of the procedure are sampling and field measurement. The data gathered using field data enable estimation of above-ground bole carbon stock. Adoption of permanent plot methods will enable long-term and periodic measurement and estimation of bole carbon stocks over any selected period. Wood density, tree volume and DBH are important driving variables when estimating above-ground biomass. The above-ground bole carbon stock estimation in IITA provides baseline information for sustainable management of the secondary forest ecosystem for optimal carbon sequestration.

REFERENCES

Aghimien, E.V., Osho, J.S.A., Hauser, S. and Ade-Oni, V.D. (2015): Forest volume to above-ground tree biomass models for the secondary forest in IITA, Ibadan, Nigeria. *Journal of Forest Research* 4.(3):1-11. Doi: 10.4172/2168-9776.1000152

Brown, S. (1997): Estimating Biomass and Biomass Change of Tropical Forests; FAO *Forest Resources Assessment Publication*: Roma, Italy, p. 55.

Chave, J., Muller-Landau, H. C., Baker, T. R., Easdale, T. A., ter Steege, H., and Webb, C.O (2006): Regional and phylogenetic variation of wood density across 2456 neotropical species. Ecological Applications 16:2356-2367

Chave, J. (2005): Measuring wood density for tropical forest trees. A field manual for the CTFS sites. Lab. Evolution et Diversite' Biologique, Universite' Paul Sabatier, 31000 Toulouse, France. Pp 1-7

Food and Agriculture Organization of the United Nations (FAO) (2009): National Forest Products Statistics, Lao PDR. In *An Overview of Forest Products Statistics in South and Southeast Asia: Forestry Statistics and Data Collection*; FAO: Bangkok, Thailand; pp. 117–184.

Food and Agriculture Organization of the United Nations (FAO) (2011): *State of World's Forest*; Food FAO: Rome, Italy. pp 95

FAO (1997): Estmating Biomass and Biomass Change of Tropcal Forests: a Primer. FAO Forestry Paper 134. http://www.fao.org/docrep/W4095E/w4095e00.htm. Accessed 2/3/2013.

Hall, J.B., Swaine, M.D., (1976): Classification and ecology of closed-canopy forest in Ghana the title is not available to be search. Department of Botany, University of Legon, Ghana, Accra, Ghana, pp. 913–951.

Hall, J.B. and D.U.U. Okali, (1979): A structural floristic analysis of woody fallow vegetation near Ibadan, Nigeria. Journal of Ecology, 67: 321-346

Husch, B., Miller,C. I., and Beers, T. W. (1972): Forest Mensuration. 2nd ed. New York: The Ronald Press Co. pp 86.

Intergovernmental Panel on Climate Change (IPCC) (2007): The Physical Science Basis: Working Group I Contribution to the Fourth Assessment Report of the IPCC; Cambridge University Press: Cambridge, UK. Pp 104

Lu, D. (2006): The potential and challenge of remote sensing-based biomass estimation. *International Journal Remote Sensing*, 27:1297–1328.

United Nations Framework Convention on Climate Change (UNFCCC) (2008): Report of the Conference of the Parties on its thirteenth session, held in Bali from 3 to 15 December 2007. Addendum, Part 2, Document FCCC/CP/2007/6/Add.1 UNFCCC, Bonn, Germany

P.K.T. Munishi, (2005): "Princinpal of Forest Ecology. A Compendium-SUA," pp 45

Reyes, G., Brown, S., Chapman, J. and Lugo, A.E. (1992): Wood densities of tropical tree species. General Technical Report SO-88, United States Department of Agriculture, Forest Service, Southern Forest Experiment Station

Wang, G.; Zhang, M.; Gertner, G.Z.; Oyana, T.; McRoberts, R.E. and Ge, H. (2011): Uncertainties of mapping aboveground forest carbon due to plot locations using national forest inventory plot and remotely sensed data. *Standard Journal of Forest Res*ources, 26: 360–373.

Zanne, A.E., Lopez-Gonzalez, G., Coomes, D.A., Ilic, J., Jansen, S., S., Lewis, S.L., Miller, R.B., Swenson, N. G., Wiemann, M.C., and Chave, J. (2009): Towards a worldwide wood economics spectrum. Dryad Digital Repository. *Dryad Digital Repository: Global wood density database.* Available at http://dx.doi.org/10.5061/dryad.234 Accessed 3/7/2015.

Sustainable Utilization of *Gnetum africanum* (Welw) in Akwa Ibom State: A Panacea for Sustainable Forest Management

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ABSTRACT

This paper discusses the strategies for sustainable utilization of forest vegetable (Gnetum africanum) (Welw) in Akwa Ibom State of Nigeria. Gnetum africanum is one of the most important leafy vegetables commonly found in the rainforest agro-ecological zone of Nigeria. However, this vegetable is threatened, due to the continuous destruction of the rainforest, high demand of this species while the rate of regeneration by both government and individual is low because little is known about its silvicultural requirements. Therefore, to reverse this lopsided situation, it is imperative to examine strategies for the sustainable utilization of this species. The strategies include: fertilization, irrigation, shade/light requirements of this species, staking and harvesting methods for domestication and its sustainable utilization.

Keywords: *Gnetum africanum*, sustainable utilization, forest management

INTRODUCTION

Gnetum africanum (Welw) is an African indigenous crop mainly grown for the leaves (Akpan *et al*; 2014). According to Dutta (1999), *Gnetum africanum* is classified as a climber because it produces vine which wind round a stake in clockwise direction. Akpan *et al.*, (2014) addded that initially *Gnetum africanum* was growing in the wild state but presently it is almost on extinction and are now cultivated in the homestead gardens. Locally, it has many names as there are ethnic groups that consume it. Ibibio and Efik call it *Afang* and in Ikom, it is called *Nkani* while the Igbos called it Ogazi or Ukazi (Ekanem, 1998). *Gnetum africanum* belongs to the family of Gnetaceae in the order of Gnetales (Dutta 1995). It is a terrestrial flora which survives mostly in the high forest and in a well conserved ecosystem and a very rich soil with plant nutrients.

This species is a seed bearing forest vegetable (Etukudo, 2000). It is more popular and is a very important leafy vegetable mostly sought after by inhabitants of the South Eastern zone of Nigeria. It is an all season vegetable that is consumed throughout the year in Nigeria. *Gnetum* holds an important place in the diet of many people in south Eastern Nigeria and nutritional value of its leaf is high. According to Oguntona (1988), proximate analysis of dried *Gnetum africaum* leaves gave a moisture content of 73.2%, 278kcal of energy, 15.2g of protein, 33.0g of crude fibre and 6g of ash. The chemical composition of *Gnetum africanum* leaf was reported by Eyo *et al*., (1983) but the particular variety used was unspecified. As shown in Table 1, the report indicated that *Gnetum* leaves had a high content of crude fibre (33.02%) and low content of crude protein (15.18%).

Table 1: Proximate composition of *Gnetum africanum* leaf

Absolute Dry Matter (%)	Crude Protein (%)	Crude Fibre (%)	Ether Extract (%)	N-free Extract (%)	Total Ash (%)
26.83	15.18	33.02	7.53	37.53	6.74

Source: Eyo *et al.*, (1983)

This vegetable additionally has a high content of non-amino acid nitrogen (37.53%). These authors further reported that the leaf is high in phosphorus (4.63%) and Calcium (6.33%). Thus, nutritional composition of this vegetable is responsible for the high demand for it by many families in Akwa Ibom State. *Gnetum* leaves serve as a source of cheap protein and are more easily within the reach of the less privilege than meat, because this can be cultivated and harvested in the home gardens. Oguntona *et al.*, (1989) stated that *Gnetum* is the fourth most proteinous Nigerian leafy vegetable out of the analysis of 31 Nigerian leafy vegetables.

Gnetum africanum apart from its nutritional values serves as the source of income. The collection of *Gnetum africanum* from the rainforest and their subsequent sales bring additional income to the farming families in the rural areas. The leaf or *Gnetum* is sold both in the rural and urban areas of Akwa Ibom State by some people who take to the trade as their fulltime means of livelihood. *Gnetum africanum* is viewed in the international market as a major source of income to households and nations. It is an economic crop that has an important role to play in poverty alleviation (Nkefor, 2000).

Medicinally, *Gnetum africanum* is used in the treatment of variety of diseases. In Nigeria, the leaves are used for the treatment of enlarged spleen, for sore throat and as cathartic (Ndam *et al*., 2001). In Ubangi, it is used to treat nausea and is considered to be an antidote to some form of poison. Bougnet (1969) reported that leaves of *Gnetum africanum* is used as dressing for watt and boils; a tisane of cut-up steam is taken to reduce pain at child birth.

The species has very high economic, social and cultural values such that there is no cultural festival or ceremony in the region which *afang* soup would not be considered as their major delicacy (Etuk *et al*., 2009).

Despite these immense benefits of *Gnetum africanum*, it is disappearing at the alarming rate due to over exploitation, difficulty in regenerating the existing ones and establishing new plantation by both government and private agencies. This is because little is known about its silivcultural requirements, especially at the nursery stage. Therefore, to reverse this lopsided, situation it is imperative to examine and adopt strategies for domestication and sustainable utilization of this species. Such strategies include;

- Propagation thecniques
- Irrigation
- Fertilizer application
- Light and Shade management
- Staking methods
- Harvesting techniques among others.

METHODOLOGY

Propagation Techniques

Gnetum africanum could be propagated by sexual and asexual methods. Sexual propagation is done by seed. Mature *Gnetum* produces seeds which could be picked form the forests and sown directly to the soil to a dept between 10 to 15cm (Ita, 2015). This author added that, the seed germinates within 14 days after sowing with adequate watering. In asexual propagation, this species is propagated by stem and root cutting and wilding from the forest. The cutting according to Ita (2015) is up to 15 to 20cm of which the length of 10cm should be buried in the soil. The cuttings according to Ita (2014), sprouted after four weeks.

Fertilizer Application

The application of soil amendment has the capacity to raise buffering capacity of the soil. Such amendment has the capacity to stop nutrient or pH changes by absorption. Hence the increase phosphorus as well as other essential nutrient is attributed to increase in pH that favourably influences nutrient availability in the soil (Brady and Well, 2005; Osemwota, 2010, Iwara *et al*., 2011). Thus such amendment could favour the growth of *Gnetum africanum* in domestication. Also Obatolu and Agboola (1993) and Agboola *et al*. (1990) have demonstrated the use of various organic nutrients for improving the organic level of the soils. Shado (1993) and Fagbenro and Fagbenro and Adeola (1981) also observed that the use of poultry waste and other organic fertilizers as effective silvicultural tools for improving the growth performance and quality of seedlings in the nursery and for hastening the growth of trees in plantation. It is therefore, imperative to have an appropriate understanding of the time, rate, methods and type of fertilizer to be applied on *Gnetum* for its sustainable utilization.

Watering (Irrigation)

Another strategy for sustainable utilization of *Gnetum africanum* is watering (irrigation). According to Nwoboshi (1982), water is the most critical environmental factor that affect the growth and development trees. This is because water is the principal constituent of protoplasm, a reagent in photosynthesis and vehicle of every physicochemical process by which life is maintained and handed on in trees. Thus a good knowledge of watering regime of *Gnetum africanum* could enhance the domestication of *Gnetum africanum* for its sustainable utilization.

Light Intensity/Shade Management

The intensity of light has important influence on the growth and development of plants. The energy necessary to sustain tree life on earth is derived directly from the sun in the form of electromagnetic waves of varying length and energy contents (Akpan *et al*., 2014). These authors added that, effects of light on tree growth depend on its quality or wave length composition, its intensity or radiance on its duration on periodicity. Seeds as well as some mature plants seem to be particularly susceptible to the relative amount of light and infra-red waves to which they are subjected. Therefore, to have sustainable utilization of *Gnetum africanum* knowledge of appropriate light intensity of this species should be considered.

Staking Methods

According to Akpan (2015), staking is defined as the act of supporting newly planted climbers, trees, crops, vegetables among many others so that they can evenly supported from within with the use of staking materials, like wood, pools, twine or rope. According to Hornby (1995), there are four methods of staking vines and they are as follows: pea-staking, single staking; stake and twin; and metal rings and linking stakes. Staking is an important factor influencing growth and development of vines. It is therefore, observed that *Gnetum africaunum* may be successfully raised for its sustained utilization if the appropriate staking method is recognized and adopted.

Harvesting Techniques

All species of *Gnetum africanum* occur as vines climbing into forest canopy. The crop is destructively harvested by cutting and then pulling the vine from the forest canopy. This harvesting method according to Blackmore (1999), always kills the plant. In the course of harvesting the vines, the buds on the tuber are damaged and it may take a long time for new buds to develop into vines. Shiembo (1999) added that, sometimes forceful pulling of vines creates wound on the tuber/root for fungal attack that can cause tuber/root not disease.

CONCLUSION AND RECOMMENDATION

Gnetum africanum plays major roles on the diets and economic emancipation of the rural farmers. Many people especially in the rural areas are dependent on the marketing of *G. Africana* for their livelihood while some are dependent for medicinal values.

Since activities of man such as deforestation, overgrazing, bush burning, and other antropogenic activities impact negetively on the survival and abundance of this species, people from both rural and urban centres should adopt the technques of sustainable management of the remaining ones. This could be done through domestication by identification and charactirization of its germplasm resources, the capture, selection and management of genetic resources and the generation and sustainable cultivation of the species in the managed ecosystem.

REFERENCES

Agboola, A. A., Fagbenro, J. A. and ObatoluC. R. 1990. The nature and the role of soil organic matter in crop production in the humid tropicc. In:Proc. International Soil Science Society, Kyoto, Japan, pp37-39

Akpan, M. P, ndaeyo, N. U and Handson, H. E. 2014. Effects Of Synthesized Plant Hormones on the Early Growth Rate of *Gnetum africanum* (Welw) in Uyo South Eastern, Nigeria. *International Journal of Basic and Applied Sciences*,3(3):89-95

Bouquet, A. 1969. Feticheurs Et Medicinces Traditionalies Du Congo (Brazaaulle),Paris:Orastom. 21-28

Dutta, A. C. 1999. Botany for degree students. Oxford University Press, Eight Edition

Etukudo, I. G., Akpan-ebe, i. N., Udofia, and Attah,V. I. 1994. Element of Forestry, Usanga and Sons Enterprise, Uyo, Nigeria, 9-43pp

Etuk, I. M.,offiong,M. O.,and Essien- Ibok, M. 2009. Economic Potentials of and Sustainable Management of *Gnetum Africanum* in Akwa Ibom State Nigeria. In: Proceedings of Conference of Forestry Associationof Nigeria Held in benin city, Edo State, Nigeria, 25th -29th October, 2010, 406-412pp

Ita, E. E., 2015. Effectsof Seedlings Sources, Fertilizer Application and Light Intensitieson Growth and Dry Matter Accomulation of *Gnetum africanum* (Welw). A Ph.D Thesis Presentedin the Department of Forestry and Natural Environmental Management, 117pp.

Iwara, A. I., Ewa, E. E. , Ogundele, F. O., Adeyemi, J. A. And Otu, C. A. 2011. Ameleoration Effects of Palm Oil Mill Inffluence on the Physical and Chemical Properties of Soil in Ugep, Cross River State, South- Southern Nigeria. *International Journal of Applied Science and Techchnology* 1(15):106-112

Ekanem, S. E. 1998. Leave Epidermal :Studies in the Genus Gnetum Home, South Easten Nigeria. A project Work (B.Sc.). University

of Uyo, Uyo Unpublished, 24pp
Etukudo, I. 2000. Forest Our Define Treasure. Uyo, Donald Publishers.198pp
Eyo,E. S., Mohme, A. and Abe, H. J. 1983. Chemical Composition and Amino Acid Content of *Gnetum Africanum*, *Hensia Crinata* and *Piper Guineese.* Nigerin Journal of Nutritional Science, 4(1):57-62pp
Oguntona, T. 1998. Green Leafy Vegetable. In :Nutritional quality of Plant Foods. Anthony N.Ogagie and Offiong, U. Eka (Eds). Post Harvest Research Unit, University Of Benin City,Nigeria. 12-33pp
Oguntona, C. R., Oduntona, B. And L. Willam 1989. Survey of Food and Nutritive Intake of Kanun of Bornu State, Nigeria. Savanna 10(2):86-89
Osemwota, O. I. 2010. Effects of Abattoir Effluence on the Physical and Chemical Properties of Soils. *Envron.Monit Assess*, 167:404-499
Obatolu, C. R., and Agboola, A. A. 1993. The Potential of Siam Weed Chromoleana Odorata as a Source of Oganic for Soil in Humid Tropics. In :Mulongoy, K. and Merchx, R. (Eds. Soil Organic Matter Dynamics and Sustainabiltyy of Tropical Agriculture. IITA/ K. U. Leuven /A. Wiley- Sayce 10- Publication, UK, 89-99pp

Vegetative Propagation of *Plukenetia conophora* Mull Arg (Walnut) using Juvenile Stem Cuttings

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ABSTRACT

Plukenetia conophora Mull ARG a liana with high economic potentials is threatened by extinction. Ex-situ conservation of the species which requires knowledge of its early growth and vegetative propagation has the potential to enhance its sustainability. Vegetative propagation potentials of juvenile double node stem cuttings of P. conophora were studied using Indo-butyric Acid (IBA), Naphthalene Acetic Acid (NAA) and a combination of IBA and NAA growth regulators at 50ppm, 100ppm and 200ppm. This was compared with the powdered form of the same growth regulators by applying to base of cuttings at a rate of 8g/kg$^{-1.}$ The control had no growth regulator application. Sterilized river sand and sawdust were used as rooting media. Result showed a significance difference between cuttings set with modified hormones of different concentrations and the powdery form with the control at P<0.05. Cuttings raised with a combination of IBA and NAA in powdery form using sawdust produced 90% rooting over the control (no rooting). The study indicates that P. conophora could be vegetatively propagated to serve as an alternative planting stock to seed. This method may circumvent the problem caused by seed scarcity and storage problem.

Keywords: *Plukenetia conophora*, vegetative propagation, rooting, cuttings, growth regulator

INTRODUCTION

Vegetative propagation or macro propagation is the means of obtaining a new plant from the original plant vegetatively which is possible because of the totipotency of the cell (the genetic information), necessary to regenerate the entire organism, Hettasch *et al.*, (2009). Vegetative reproduction comprises a broad range of techniques involving the manipulation of plant tissue samples, (selection of stem, leaves, roots or even cell culture) which ultimately allows for complete regeneration of the whole plant. The end results are genetically identical individuals, clones, varieties or lines, Yanchuck (2001). Since seeds of most tropical forest trees are not regularly available either due to irregular flowering and fruiting phenologies or recalcitrant nature of the seed, it follows that effective method (s) of stock plant management must be devised. This is necessary to ensure all year round production of cuttings in nursery for large scale production programmes.

Plukenetia conophora Mull ARG is a woody perennial climber (liana) with high potentials to meet the fundamental needs of man which are basically food, good health services and raw materials. Inspite of its numerous uses, propagation of *P. conophora* is limited by its recalcitrant seeds which disappear almost immediately after the fruiting season as a result of high consumption by man, rodents and post harvest deterioration due to poor storage, Awodoyin *et al* (2000). However, vegetative propagation has been suggested as an alternative planting stock to seeds of such species, Oni (1995). Hence, this study was carried out to determine how best *P. conophora* could be vegetatively propagated using stem cutting to circumvent the problem of its recalcitrant seeds.

MATERIALS AND METHODS

One hundred (100) ten months old uniformly growing seedlings which were maintained as ortet base were used to produce juvenile stem cuttings for this experiment. These young shoots were severed from the ortets with secateurs, into a bucket containing three (3) litres of water to prevent transpiration.

The shoots were further reduced to double node cuttings (A total of four hundred) using a sterilized surgical blade fixed unto a feather. The leaves on them were reduced into half to prevent excessive transpiration and at the same time, aid photosynthesis. The double node cuttings were subjected to four growth regulators treatments viz.

i. Indole 3 - butyric acid (IBA)
ii. Naphthalene acetic acid (NAA)
iii. A combination of IBA + NAA.
iv. No growth regulator

(a) The growth regulators were applied at three (3) levels of concentration, 100ppm, 150ppm 200ppm and a control (no growth regulator) according to the standard used in Forestry Research Institute of Nigeria (FRIN). The quick dip method, Oni (1987) was applied.

(b) The experiment was repeated using the same type of growth regulators, (IBA, NAA and IBA + NAA) in powder form at a rate of $8g/kg^{-1}$ applied to the base of the cutting. Hettasch *et al* (2009). The cuttings were set in plastic germination trays containing washed sterilized river sand, and some in saw dust at the rate of 20 cuttings per tray with five replicates per treatment. Trays were placed under a humid propagator in a complete randomized design. Watering was done daily to field capacity using a knapsack sprayer. Variables assessed after sixty (60) days include the following.

(i) Percentage survival
(ii) Percentage rooted cutting
(iii) Percentage callused cuttings
(iv) Number of roots per cutting
(v) Length of longest root per cutting.

Data were subjected to analysis of variance.

RESULTS AND DISCUSSION

RESULTS

Survival Percentage of cuttings

Percentage survival of cuttings varied among the different types and state of growth regulators (Table1). Interaction between the different types of growth regulator showed a significant difference at $P<0.05$. The highest survival percentage 100% (80% rooted cutting + 20% callused cutting) was obtained among cuttings set with NAA+IBA powder growth regulator using sawdust as a sowing medium (Table 1). A highest percentage of surviving rooted cuttings (80%) was recorded in NAA growth regulator using sand as sowing medium. In IBA, the highest percentage surviving rooted cuttings was also 80% recorded in cuttings set in sawdust medium while in NAA + IBA, the highest percentage of surviving rooted cutting was 90% (Table 1). The control had 0% because the cuttings did not root at all.

Number of roots per cutting

Interaction between type of powder growth regulator and potting media indicated a significant effect on the number of roots produced $P<0.05$. The highest mean number of roots 13 was produced by NAA + IBA hormone using saw dust (Table 1). The least mean number of roots (3) was produced by NAA hormone using saw dust. IBA recorded a high number of roots 8 while the control did not produce any roots at all (fig1).

Root Length

Interaction between hormone type and type of rooting media did not have any significant effect on root length. Although the longest tap root of 3.12cm was recorded in IBA growth regulator using sand as a sowing medium, it was not significantly different from those produced by NAA and NAA + IBA.

Table 1: Survival and Mortality among cuttings of *Plukenetia conophora* using powdered hormones (NAA)

NO SET	Surviving No rooted no (%)		Surviving Callused No (%)		Dead No (%)	
NAA	**Sand**	**Saw dust**	**Sand**	**Saw dust**	**Sand**	**Saw dust**
20	12(60%)	13(65%)	3(15%)	5(25%)	5(25%)	2(10%)
	8(40%)	11(55%)	4(20%)	3(15%)	8(40%)	6(30%)
	15(75%)	11(55%)	2(10%)	-	3(15%)	9(45%)
	11(55%)	9(45%)	1(5%)	4(20%	8(40%)	7(35%)
	16(80%)	13(65%)	-	4(20%)	4(20%)	3(15%)
	12.4(62%)	**11.4(57%)**	**2.5(12.5%)**	**4.(20%)**	**5.6(28%)**	**5(27%)**

IBA						
20	12(60%)	12(60%)	2(10%)	6(30%)	6(30%)	2(10%)
	10(50%)	14(70%)	3(15%)	4(20%)	7(35%)	2(10%)
	11(55%)	12(60%)	3(15%)	2(10%)	6(30%)	6(30%)
	14(70%)	16(80%)	2(10%)	4(20%)	4(20%)	--
	9(45%)	8(40%)	4(20%)	7(35%)	7(35%)	10(50%)
	112(56%)	**12.4(62%)**	**2.8(14%)**	**14.4(18%)**	**6(30%)**	**5(25%)**
NAA+IBA						
20	14(70%)	13(65%)	2(10%)	5(25%)	4(20%)	2(10%)
	11(55%)	14(70%)	6(30%)	3(15%)	3(15%)	3(15%)
	16(80%)	14(70%)	--	3(15%)	4(20%)	3(15%)
	13(65%)	18(90%)	4(20%)	--	3(15%)	2(10%)
	17(85%)	16(80%)	--	4(20%)	3(15%)	--
	14.2(71)	**15(75)**	**4(20%)**	**3.75(18.75%)**	**3.4(17%)**	**2.5(12.5)**
Control	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)

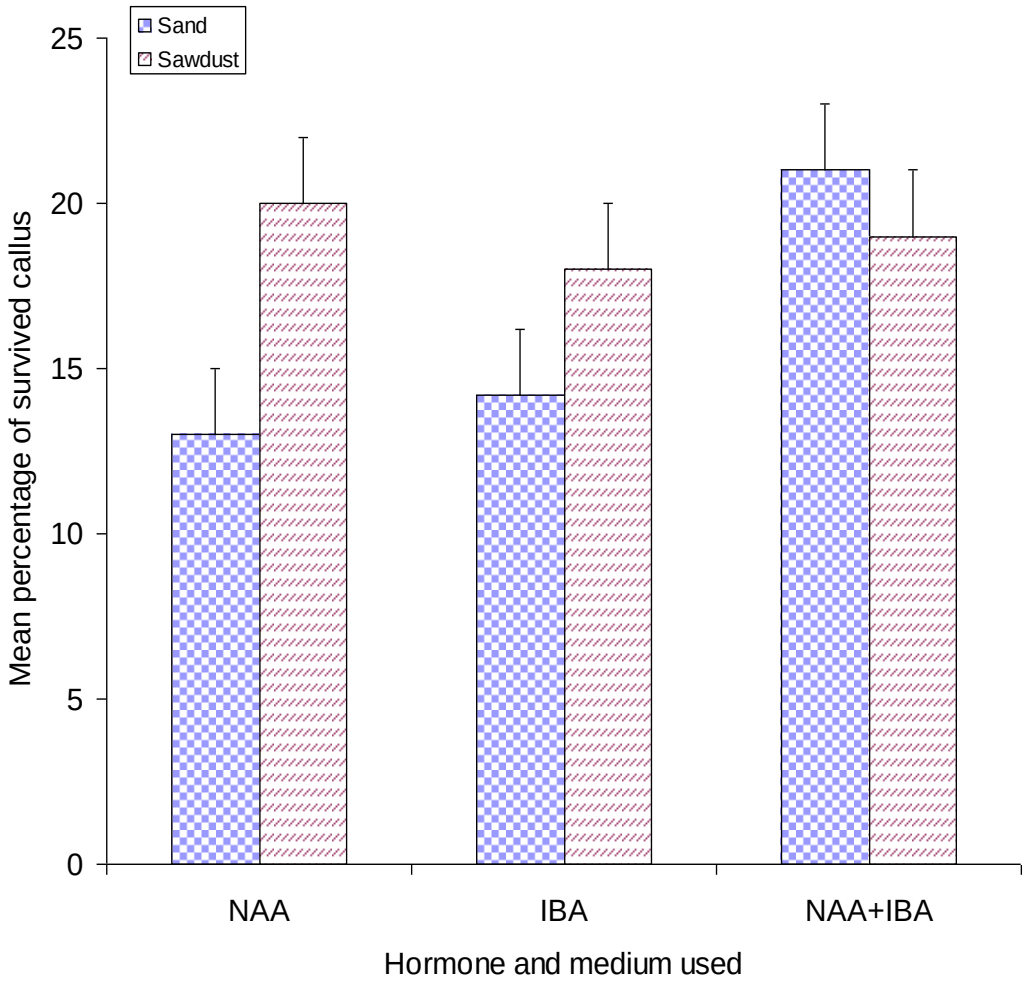


Figure 1 Mean percentage of rooted cuttings using NAA, IBA and NAA+IBA powder growth regulator in sand and saw dust.

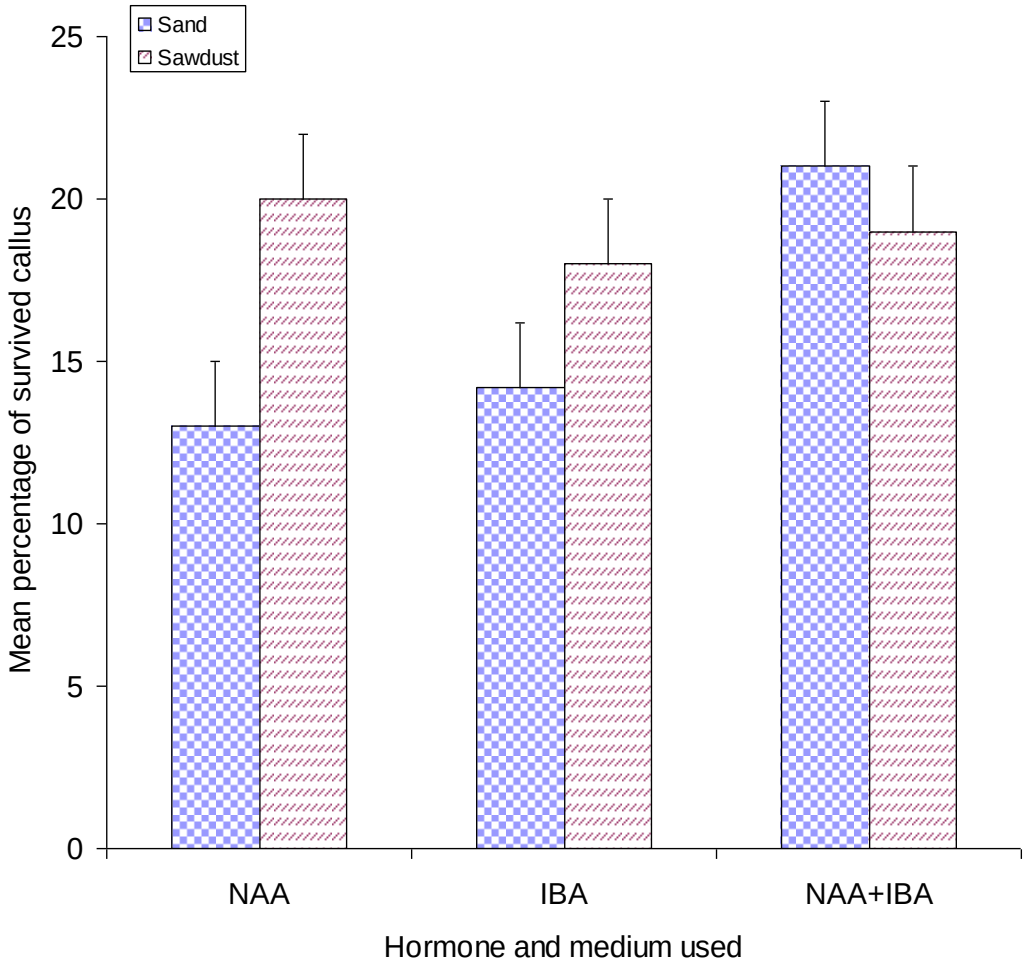


Figure 2 : Mean percentage survived callus in sand and sawdust media



Plate 1: Double node cuttings of *P. conophora* at 7 weeks showing the developing roots



Plate 2: Double node rooted cuttings of *P. conophora* at 8 weeks



Plate 3: Double node cuttings of *P. conophora* treated with IBA powder at 8 weeks .

DISCUSSION

The use of vegetative propagation makes it possible to capture and transfer to the new tree all the genetic potential (additive and non-additive variation) from the Ortet for certain characteristics. With low narrow-sense heritability, it has been demonstrated that genetic gains can be doubled by using vegetative propagation. Hettasch *et al* (2009) and P.kiuru *et al.* (2015). Another valuable advantage is that in some situations, vegetative propagation can contribute to accelerating the realization of results from tree improvement activities, since the desired genetic qualities of selected trees can be utilized rapidly without having to wait for seed production, before producing propagules for operational planting. This is the case of *P. conophora*, a seasonal fruiting liana with recalcitrant seeds.

The possibility of rooting double node stems cuttings of *P. conophora* is crucial to its multiplication and germplasm conservation strategy. Most plant species require plant regulators at varied concentrations to enhance the rooting potentials of their nodal cuttings. In this study, juvenile double node cuttings of *P. conophora* were treated with varied concentrations of indole 3- butyric acid (IBA), Naphthalene acetic acid (NAA) and a combination of IBA+ NAA at 100ppm, 150ppm and 200ppm. Two leaves halved in size were left on the cuttings for photosynthesis and to produce rhizocaline, an unidentified rooting co-factor which enhances rooting, Herman *et al* (1991). These treatments produced a negative result contrary to studies by Gbadamosi (2002), Akinyele (2007) who worked on vegetative propagation of *Enantia Chlorantha* and *Buchholzia coriacea* Engler respectively using juvenile stem cuttings. However, cuttings of *P. conophora* produced successful results using powdery form of IBA, NAA and IBA+ NAA at a rate of 8g kg-1 applied to the base of the cutting, a standard used by the Centre for Scientific Research (CSIR) South Africa(.plate1) These findings were in agreement with Hettasch *et al* (2009) who applied IBA plant regulator in powdery form at 8g kg-1 on *Pinus elliottii* and *Pinus caribaea* cuttings, and recorded 90% rooting with an increase in quantity and quality of roots produced. Using sand or sawdust as a rooting medium did not show any significant difference. But form and type of plant regulator had a significant difference from the control (no plant regulator). Indicating that *P. conophora* is not an "easy rooter".

The possibility of rooting this species may solve the problem of non – availability of seeds at the off season periods and the effect of consumption by man and rodents. Cuttings have been widely used in clonal propagation of forest trees, where large number of planting stocks are required and recently in local fruit trees like *Irvingia gabonensis, Ricinodendron hedelotii, Dacryoides edulis*. Also

in medicinal plants like, *Prunus Africana* and *Pausinystallia jobimbe* as recorded by various authors including, Mialoundama *et al* (2002), Tchoundjeu *et al* (2002) Ngo mpeck *et al* (2003) and P.kiuru *et al* (2015)

CONCLUSION

The use of vegetative propagation makes it possible to capture and transfer to the new tree all the genetic potential (additive and non-additive) variation from the ortet. Vegetative propagation can contribute to accelerating the realization of results from tree improvement activities since the desired genetic qualities of selected trees can be utilized rapidly without having to wait for seed production as the case of *P. conophora*, a seasonal fruiting liana with recalcitrant seeds. The possibility of rooting this species is crucial to its multiplication and germplasm conservation strategy.

REFERENCES

Akinyele A. O. 2007: Silvicultural requirements of seedlings of *Buchholzia coriacea Engler*. Unpublished Ph.D Thesis. University of Ibadan Nigeria 175 pp.

Awodoyin, R. O., Egunjobi, J. K., Ladipo, D. O. 2000: Biology germination and prospect for the domestication of conophor nut *Plukenetia conophora* mull Arg. Syn *Tetracarpidium conophorum* in *Journal of Tropical for Resources* Vol. 16 1.

Gbadamosi A. E. 2002: Domestication of Enantia Chlorantha Olive-A medicinal plant. Unpublished Ph.D thesis. University of Ibadan, Nigeria. 192 Pp.

Herman, B.; Denison, N. P. Friedman, G. Le Roux, J. J. and Mckellar D. 1991: Bio-technology/vegetative propagation in MONDI, IUFRO Symposium. Proceedings. Intensive Forestry, The role of Eucalypts. Durban, South Africa 94 – 103.

Hettasch, M. H., Eatwell, K. A., Fossey A., Pierce, B. T. Snedden, G. L. , Steyn D. J., Venter, H. M. and Verryn, S. D. 2009: Tree Breeding course Manual. Natural Resources and the environment, CSIR. Pretoria, South Africa.

Kiuru,P, Muriuku, S.J.N, Wepukhulu S.B, and Muriuki, S.J.M. 2015:Influence of growth media and regulators on vegetativepropagation of rosemary. (*Rosmarinus officinalis* L) *East African Agricultural and forestry Journal* Pp. 105-111.

Mialoundama, F., Avana, M.L., Youmbi, E, Mampouya, P.C., Tchoundjeu, Z., Mbeuyo, M., Galamo, G.R, Bell, J.M., Kopejuep, F., Tsombeng, A.C., Abega, J. (2002): Vegetative Propagation of *Dacryodes edulis* (G. Don) H.J> Lam by macrocots, cuttings and micropropagation. Forest Trees and Livelihoods. Vol 12 Pp.85 – 96.

Ngo Mpeck, Marie-Laure, Zac Tchoundjeu and Ebenezer Asaah 2003: Vegetative propagation of *pausnystalia johimbe*, K. schum by Leafy stem cuttings. *Journal of propagation of Ornamental plants.* Vol. 3 No. 2, 2003 11 – 18.

Oni, O. 1987: Effect of auxin on the rooting of stem cuttings of *Terminalia superb* (Engl and Diels. Ed. A.B. Oguntala). The role of forestry in a despressed economy, proceedings of the 17th Annual Conference of the Forestry Association of Nigeria., 6 – 10 December 1987. Ikeja, Lagos State Nigeria. P. 312.

Oni, O. 1995:Management and maintenance of stock plants for effective vegetative propagation of forest tree species, paper presented at the training Workshop on the training Workshop on the vegetative propagation of Forest Trees, organized by Extension Research and Liaison section (ERLS) FRIN 7 – 11 Nov. 1995. Iwo, Osun State. 15pp.

Tchoundjeu, Z., Avana, M.L., Leakey, R.R.B., Simons, A.J. Asaah, E., Duguma, B and Bell, J.M. (2002): Vegetative propagation of *Prunus africana*. Effect of rooting medium, auxin concentration and leaf area. *Agroforestry systems* 54:183 – 192.

Yanchuck, A. D. 2001: The role and implications of Biotechnological tools in Forestry, *Unasylva* 204 Vol. 52 Pp. 53 – 60.

Influence of Organic Manure on the Growth of *Kigelia africana* (Lam.) Benth. Seedlings

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ABSTRACT

Kigelia africana (Lam) Benth. is generally considered to be a highly variable monospecific genus of the family Bignoniaceae and sacred to many African communities (e.g. Kenya). This study is aimed at investigating the seedling growth performance of Kigelia africana in different growing media so as to determine the best growing medium in raising Kigelia africana seedlings for the establishment of healthy vigorous plantation. The fresh seeds of K. africana were sown into sterilized river sand to avoid pre-emergence damping – off and the germination percentage was calculated using standard formula. There are four treatments replicated ten times making a total of forty polythene pots. The experiment was laid down in a Completely Randomized Design (CRD). The parameters assessed to monitor the growth performance of K. africana seedlings are; Germination percentage (%), Plant height, Stem diameter and Leaf production count. The data collected were subjected to Analysis of variance (ANOVA), while the significant means were differentiated using Duncan Multiple Range Test (DMRT) at 5% level of probability. The result of this study established that organic manure had an influence on the height, leaf count and stem girth of Kigelia africana. Also, the organic manure that best suit the growth of Kigelia africana is poultry manure. The result from the analysis of variance (ANOVA) indicated that there are significant differences in all the treatments at 5% level of probability. The best organic manure should be applied to soil few weeks before transplanting so as to enhance the growth of Kigelia africana seedlings for vigorous and healthy plantation establishment in order to prevent the tree from going into extinction.

Keywords: *Kigelia africana*, Bignoniaceae, pre-emergence damping-off, germination percentage, organic manure

INTRODUCTION

Kigelia africana (Lam) Benth. belongs to the family Bignoniaceae. It is commonly called sausage tree due to its long sausage-like fruit and locally known as Pandoro (West Nigeria) (Aiyelola and Bello, 2006). *Kigelia* is generally considered to be a highly variable monospecific genus of the family Bignoniaceae (Saini *et al*., 2009). Grace *et al.* (2002) elucidated that, the previous thought on the species was that there were ten different species of *Kigelia*, but only one is presently recognized by botanists. In East Africa two subspecies are recognized, *K. africana* subsp. *africana* growing in grasslands and woodlands and *K. africana* subsp. *moosa* in tropical forests. *K. africana* is a semi-deciduous to deciduous tree that grows up to 25 meters tall. It is native to Africa and widely distributed throughout the savannah areas of tropical Africa (Grace *et al.*, 2002). It can be found growing in open woodlands and moist places such as riverbanks on alluvial soils including river banks/ floodplains of Nigeria, Cameroon, Kenya, Guinea, and Senegal. *K. africana* can also be found in open woodland from KwaZulu-Natal (South Africa) to Tanzania, Chad, and Namibia (Burkill, 1985).

The tree is widely grown as an ornamental plant in the tropical regions for its decorative flowers and unusual fruit. *Kigelia africana* is a suitable tree which stabilizes riverbanks when planted, while its broad canopy makes it a good shade tree in the open savannah. Depending on the climate, the sausage tree is remarkably fast-growing and reaches maturity in 4 to 5 years. With its fast growth rate, spreading canopy, interesting flowers and fruit, *Kigelia* is a popular street tree in South Africa and is grown to provide shade in Australia (Irvine, 2006).

The stem-bark is grey and smooth on the younger tree but peels on older trees with thickness of 5 mm. The wood is pale brown or yellowish in color, and not prone to cracking (Roodot, 1992). The leaves are opposite or in whorls and are in groups of three at the ends of the branches and are 10-20 cm long with 3-8 leaflets. The inflorescence is a panicle, 30-80 cm long. The tubular flowers are dark red with yellow veins, and have an unpleasant smell. The fruits are sausage-shaped, 30-90 cm long and 7.5-10 cm in diameter. It

flowers between the months of August and November (Joffe, 2003). Flowers are bisexual, very large; pedicel up to 11 cm long up which is curved at tip; calyx shortly tubular to campanulate, 2 to 4.5 cm long, suddenly widening and incurving upwards, limp 2-lipped, with the super or lip 2-lobed, the lower one 3-lobed and recurved (Grace *et al*., 2002). The flower scent is most notable at night, indicating their reliance on pollination by bats which visit them for pollen and nectar. The huge, grey-brown fruit is a woody berry 30 to 100 cm long and up to 18 cm wide. It weighs between 4 to10 kg and hangs from a long and fibrous stalk (Azu, 2010). The fruit is fibrous and pulpy, containing numerous hard seeds which are inedible to humans. However, several species of mammals eat the fruits/seeds, for example baboons, bush pigs, monkeys, porcupines, savannah elephants, giraffes and hippopotamus. The seeds are dispersed via their dung.

The sausage tree is considered sacred to many African communities (e.g. Kenya) and has a wide variety of uses in traditional as well as Western medicine, including commercially available skin lotions (Maundu and Tengas, 2005). *Kigelia africana* is an important tree for many people and has a wide range of uses. Both ripe and unripe fruits are poisonous to humans but the fruits can be dried and fermented, and used along with the bark to enhance the flavour of traditional beers (Maundu and Tengnas, 2005). The seeds are sometimes roasted and eaten in times of food shortage. The wood makes good quality timber for fences, planking, boxes and canoes (Bidgood et *al*., 2006).

Kigelia africana is widely used throughout Africa for a variety of purposes, particularly in local medicine, and more recently in commercial applications to treat various skin complaints (Azu, 2010). The diversity of complaints against which the plant is used includes fainting, anaemia, sickle-cell anaemia, epilepsy, respiratory ailments, hepatic and cardiac disorders, and nutritional illnesses such as kwashiorkor, rickets, wasting and weakness. The leaves are sometimes used to prepare a general tonic for improved health and growth (Burkill, 2000). Aqueous fruit preparations are applied as a wash or rub to promote weight gain in infants. The roots, bark, leaves, stems, twigs and fruits are used to treat digestive disorders. Administration is typically by oral ingestion or as an enema. The root, bark and ripe or unripe fruits are taken as a laxative or emetic, to treat chronic and acute digestive disorders and against gastric infections (Akunyili *et al*., 1991).

Despite the importance of *K. africana*, its plantation and the tree is scarce to get in the environment, which makes its establishment very important in order to prevent the species from extinction. However, Organic manure is a silvicultural tool which helps to improve the vigour and stimulate the growth of *K. africana* seedlings so as to meet its demand for plantation establishment. Hence, this research is in right order to harness the best growing medium for raising *K. africana* seedlings.

MATERIALS AND METHODS

The fresh fruits of *K. africana* were harvested from its mother tree at Iwo, Osun state in April, 2015, after which the fresh seeds were extracted from them with the aid of knife. The river sand, Poultry manure, Cowdung and Top soil were obtained within the Federal College of Forestry, Ibadan. The seeds extracted were sowed directly into the basket filled with sterilized river sand to avoid pre-emergence damping off. The germination was noticed on the fifth day of sowing and the germination percentage was calculated. The growth was monitored for three weeks before being transplanted into the polythene pots. The polythene pots were filled with the mixture of top soil and organic manure (poultry manure and cow dung) that had been air dried and then ground into powder for easy mixing and fast decomposition in the soil. The mixtures were watered for a period of three (3) weeks in order to hasten decomposition and mineralization as well as to avoid reduction in the concentration of organic manure before the seedlings were transplanted. There are four treatments replicated ten times making a total of forty polythene pots. The experiment was laid down in a Completely Randomized Design (CRD). The seedlings of *K. africana* were then transplanted into polythene pots and watered immediately. The initial measurements (ranged between 2.00 and 2.01) were taken and weekly observations were recorded accurately.
The four treatments were as follows:
T_1- 2kg of top soil+ 0.025kg of poultry manure
T_2- 2kg of top soil +0.025kg of cow dung
T_3- 2kg of top soil +0.0125kg of poultry manure+0.0125 of cow dung
T_4- Control- 2kg of top soil.

Parameters Assessed

The parameters assessed to monitor the growth performance of *K. africana* seedlings are: Germination percentage (%)**:** The percentage of germination was derived by dividing the total number of seed germinated by the total number of seeds sown multiply by 100.

Number of seeds germinated/ total number of seed sown × 100

Plant height: The height of each plant was measured from the root collar to the tip of the terminal for each bud with the aid of a graduated ruler in (cm).

Stem diameter: The stem diameter of each seedling was measured with the aid of a vernier caliper.

Number of leaves: The total number of leaves on plant seedlings was recorded for each treatment.

The data collected were subjected to Analysis of variance (ANOVA), while the mean of the results were later differentiated using DMRT (Duncan Multiple Range Test) at 5% level of probability.

RESULTS AND DISCUSSION

Germination percentage (%)

$$\frac{\text{Number of seeds germinated}}{\text{Total number of seed sown}} \times 100$$

$$\frac{230}{300} \times 100$$

$$0.77 \times 100$$

Germination percentage = 77%.

The result of germination percentage revealed that *Kigelia africana* can be raised at nursery stage without the application of any pre-treatment measure and the seedlings will be vigorous and healthy. However, more research should be done to increase its germination percentage potential. The result (Figure 1) revealed that seedlings of *Kigelia africana* responded well to poultry manure from the first week of transplanting. All the organic manure used had better growth height than the topsoil but poultry manure had the best performance than the others. Furthermore, the result from the analysis of variance (ANOVA) indicated that there were significant differences in the treatments at 5% level of probability and this led to further differentiation of mean using Duncan Multiple Range Test (DMRT). This corroborates with the work of Adekiya and Agbede (2016), which established that application of poultry manure showed significant difference in plant height, leaf area, and number of fruits per plant and fruit weight on *Lycopersicon esculentum* Mill. The result from Figure 2 also indicated that seedlings treated with manure had better performance in stem girth better than the control, with the mean values ranging from 2.46 mm – 2.84 mm, while the least performance in plant girth was observed in topsoil. The result from the analysis of variance (ANOVA) revealed that there were significant differences in the treatments at 5% level of probability. The organic manure favoured the leaf production count but cow dung had best leaf production count. The Analysis of variance (ANOVA) revealed significant differences among the treatments used at 5% level of probability. The result is in line with assertions of Mader *et al*. (2002), that organic nutrients increase the abundance of soil organism by providing organic matter and micronutrients for organisms which aid plants in absorbing nutrients.

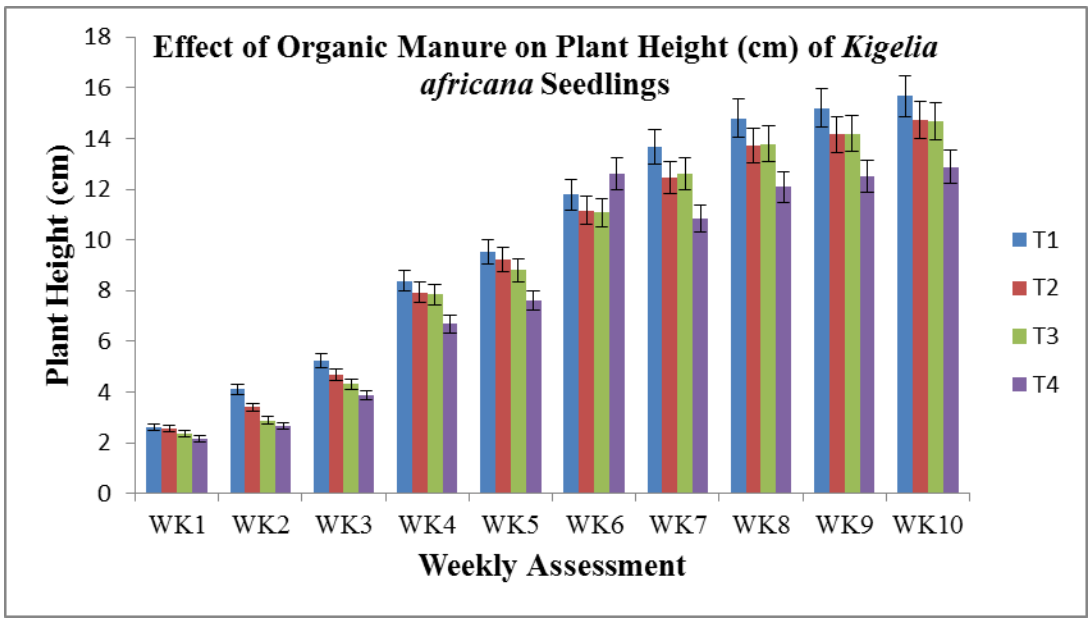


Figure 1: Effect of Organic Manure on Plant Height (cm) of *Kigelia africana* Seedlings

It is observed that the treatments are week dependent on the plant height. As the organic manure decomposes and mineralizes, the plant height increases. Also, at the end of this study poultry manure showed outstanding performance.

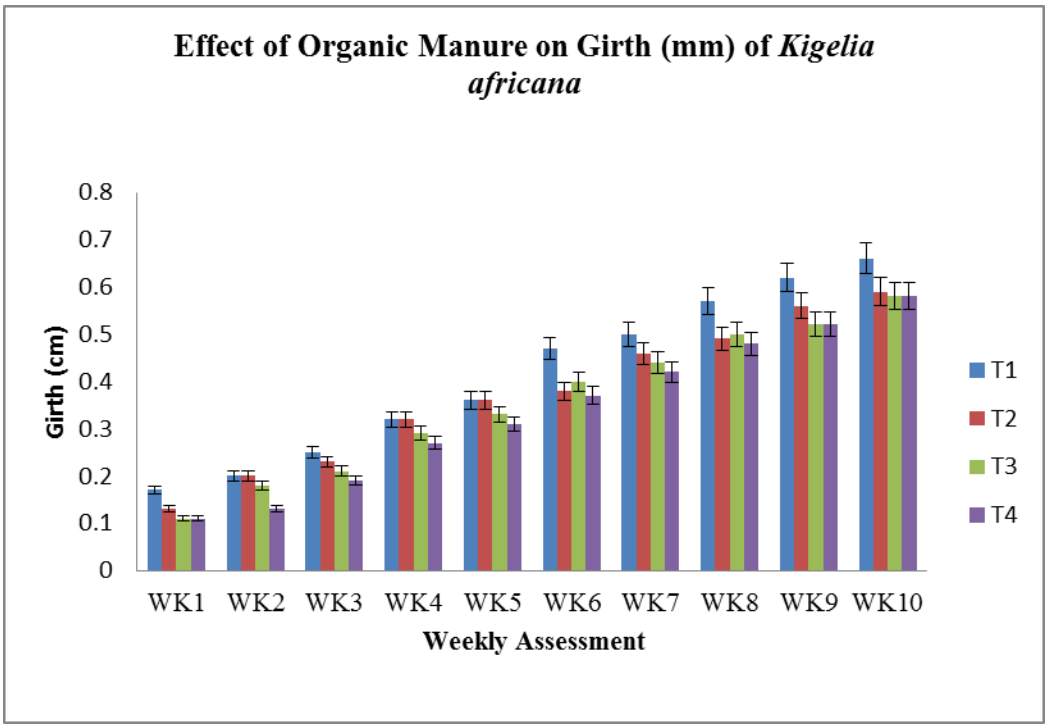


Figure 2: Effect of Organic Manure on Girth (mm) of *Kigelia africana* Seedlings

The result of the effect of organic manure on the stem girth (mm) revealed appreciable increase in the stem girth weekly with poultry manure having the best influence than the other treatments. However, at the tenth week control tends to compete with the combination of poultry manure and cowdung. This indicated that it is not normal to combine the organic manure used to form a single treatment on *K. aficana* seedlings.

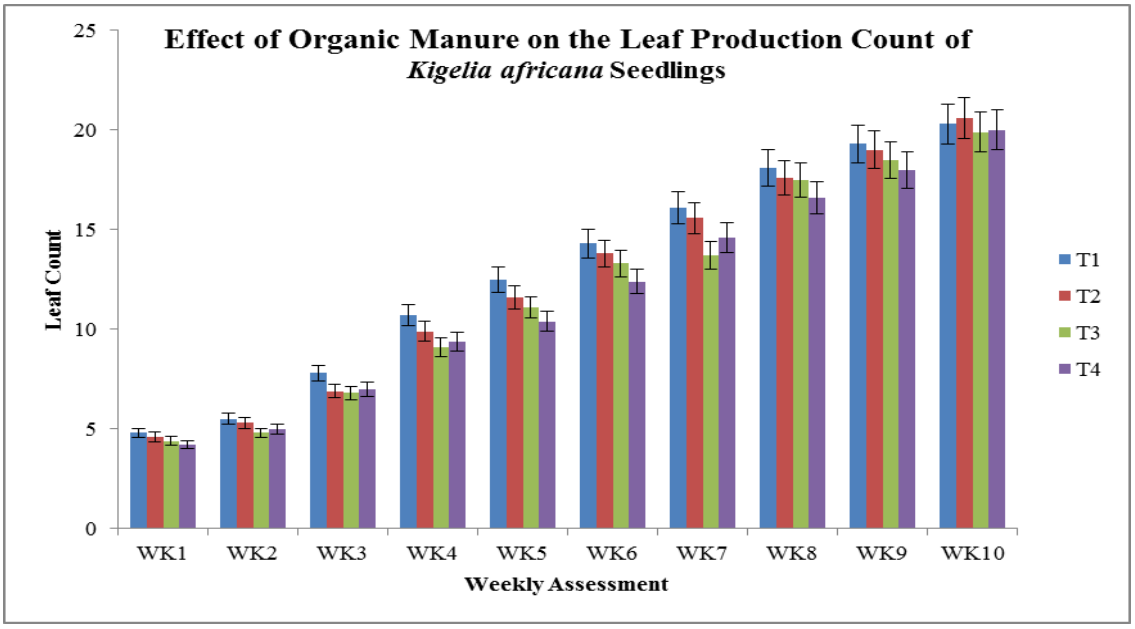


Figure 3: Effect of Organic Manure on the Leaf Production Count of *Kigelia africana* Seedlings

This result revealed that the organic manure had better influence on the production of leaves of *K. africana* seedlings. But at tenth week, the performance of cowdung slightly outstand poultry manure this indicated that if production of leaves is the paramount objective of managing *K. africana* plantation, cowdung can be the best organic manure to be used.

CONCLUSION AND RECOMMENDATION

The result obtained from this study established that organic manure had an influence on the height, leaf count and stem girth of *Kigelia africana*. Also, the organic manure that best suit the growth of *Kigelia africana* is poultry manure this may be due to its slightly alkaline nature and presence of appreciable amount of essential nutrients. Therefore, 0.025kg of poultry manure applied to the soil prior to transplanting of seedling has an area of capacity for fast growth and yield of *Kigelia africana* seedlings. This result is in line with assertion of Mader and Andreas (2002), which stated that organic nutrients increases the abundance of soil organism by providing organic matter and micro-nutrients for organisms which aids plants in absorbing nutrients. It also supports the findings of Adekiya and Agbede (2016), that application of manure to soil few weeks before planting helps in fast growth of seedlings.
In view of this, it is recommended that poultry manure at 0.025kg level should be applied to soil few weeks before transplanting so as to enhance the growth of *Kigelia africana* seedlings for vigorous and healthy plantation establishment in order to prevent the tree from going into extinction.

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REFERENCES

Adekiya, A.O. and Agbede, T.M. (2016). Effect of methods and time of poultry manure application on soil and leaf nutrient concentrations, growth and fruit yield of tomato (*Lycopersicon esculentum* Mill). *Journal of the Saudi Society of Agricultural Sciences* 10: 1016.

Aiyelola, A.A. and Bello, O.A. (2006). Ethno-Botanical Potentials of Common Herbs in Nigeria: A case study of Enugu state. *Educational Research and Reviews* 1(1):16-22.

Akunyili, D.N., Houghton, P.J., Roman, A. (1991). Antimicrobial Activities of the Stem of *Kigelia pinnata*. *Journal of Ethnopharmacology* 35: 173-177.

Azu, O.O. (2010). The Role of *Kigelia africana* Fruit Extract against Cisplatin-induced Testicular Damage in Sprague-Dawley rats. *PhD Thesis, University of Lagos*, Nigeria Pg: 63.

Bidgood, S., Verdcourt, B. and Vollesen, K. (2006). Bignoniaceae. Flora of Tropical East Africa. *Royal Botanic Gardens, Kew, Richmond, United Kingdom.* Pg: 1–47.

Burkill, H.M. (1985). The Useful Plants of West Tropical Africa. *2nd Edition. Volume 1, Families A–D. Royal Botanic Gardens, Kew, Richmond, United Kingdom* 1:254-257.

Burkill, H.M. (2000). The Useful Plants of West Tropical Africa. *2nd Edition. Volume 5, Families S–Z. Royal Botanic Gardens, Kew, United Kingdom* Pg: 686.

Grace, O.M., Light, M.E., Lindsey, K.L., Moholland, D.A., Staden, J.V., Jager, A.K. (2002). Antibacterial Activity and Isolation of Antibacterial Compouds from Fruit of the Traditional African Medicinal Plant, *Kigelia africana*. *South African Journal of Botany* 68: 220-222.

Joffe, P. (2003). *Kigelia africana* (Lam.) Benth. Pretoria *National Botanical Garden* (www.plantzafrica.com. Accessed 19th June 2009)

Mader, P. and Andreas, F. (2012). "Soil Fertility and Biodiversity in Organic Farming". *Science* 296 (5573): 1694-1697.

Maundu P. and Tengnas B. (2005). Useful Trees and Shrubs of Kenya. *World Agroforestry Centre – Eastern and Central Africa Regional Programme, (ICRAF -ECA), Nairobi, Kenya*. Technical Handbook No. 35

Roodot, V. (1992). *Kigelia africana* in: The Shell Field Guide to the Common Trees of the Okavango Delta and Moremi Game Reserve. *Gaborone, Botswana: Shell Oil Botswana* p. 43.

Saini, S., Kaur, H., Verma, B. and Singh, S. (2009). *Kigelia africana* (Lam.) Benth—An Overview. *Natural Products Radiance* 8(2):190-197.

Growth Characteristics of *Mansonia altissima* A. Chev. Seedlings Grown Under Contrasting Light Conditions

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ABSTRACT

The study investigated the influence of light intensities on the early growth performance of Mansonia altissima in other to create a favourable condition for good growth. Seedlings of M. altissima were monitored under five light intensities namely: under tree canopy (5%), 25%, 50%, 75% light intensities and control treatment was direct sunlight (100% light intensity). The study was carried out in a completely randomized design and for the period of 6 months. The different light intensities did not significantly affect the height but significantly affect the collar diameter, leaf production and leaf area of M. altissima seedlings. Biomass accumulation of M. altissima seedlings was not significantly affected by the different light intensities. The result revealed that the early growth characteristics of M. altissima seedlings depend on the amount of light intensity received while biomass accumulation do not depend on the amount of light intensity received. Tree seedlings placed under different light intensities that caused changes in growth features might not have any effect on the biomass accumulated.

Keywords: Environmental factors, light intensity, propagation, early growth, biomass accumulation,

INTRODUCTION

Forests play important role in global, national and local economies, especially in restructuring the socio-cultural life of the people and quality of the environment (Siaw*et al*., 2014). In Nigeria, forest provide goods such as timber and other non-timber products (e.g. chewing stick, bamboo, fruits, mushroom, medicine etc.) which help in the development of livelihood in most rural communities. Forest are essential due to the wide variety of goods and services they provide (Siaw*et al*., 2014).

Despite the importance of these forest resources, they are under threat from anthropogenic activities (FAO, 1999). These activities have resulted in the loss of some plant species and a decline in environmental quality as well as in the biodiversity conservation status of the forest. In addition, the forests in Nigeria are not being managed sustainably, thus exposing the species in them to dangers of extinction (Onyekwelu *et al*., 2013). Attempts made to establish large plantations of some forest tree species such as *Vitex doniana*, *Diospyrous mespiliformis*, *Entandrophragma angolense*, *Milicia excelsa*, *Mansonia altissima*, etc. have shown little or no success due to inadequate knowledge about the mode of planting, nursery techniques and early growth behavior, that will guarantee effective growth and development (Akinyele, 2013; Leakey, 2004; Rafiqul*et al*., 2004).

Mansonia altissima belongs to the family *Sterculiaceae* (Irvine, 1961). It is a deciduous forest species growing up to 37 m in height and girth of 2.5 m, bearing a dense canopy and deciduous in dry season (Irvine, 1961). *M. altissima* has been described as vulnerable according to the IUCN Red list of threatened species (IUCN, 2014). Conservation effort to promote rapid propagation of this economic species is desirable. This will reverse the current trend of the species to extinction. (Maku, 2014). Many factors are known to be related to tree growth and development. Among these factors is light intensity. It has been established that light intensity influences the early growth of tree seedlings (Wang, 2006; Adewunmi, *et al*., 2014; Bolanle-Ojo *et al*., 2014a; Bolanle-Ojo *et al*., 2014b; Bolanle-Ojo *et al*., 2015;) This underscores the need for a study that will investigate the effect of various light intensities on the early growth performance of *M. altissima* seedlings.

MATERIALS AND METHODS

Experimental Site

The screen house experiment was carried out at the Department of Sustainable Forest Management, Forestry Research Institute of Nigeria (FRIN), Ibadan, Oyo State. FRIN is located on the longitude $07^0$23'18"N to $07^0$23'43"N and latitude $03^0$51'20"E to $03^0$51'43"E. The climate of the study area is the West African monsoon with dry and wet seasons. The dry season is usually from November through March and is characterized by dry cold wind of harmattan. The wet season usually starts from April to October with occasional strong winds and thunderstorms. Mean annual rainfall is about 1548.9 mm, falling within approximately 90 days. The mean maximum temperature is 31.9^0C, minimum 24.2^0C while the mean daily relative humidity is about 71.9% (FRIN 2015).

Experimental Procedure

Twenty-five (25) seedlings (two weeks old) of *M. altissima* with uniform sizes were used in this experiment. 12 x 24 cm size of polythene bags were used and loamy soil serve as the medium for growth of the seedling. Five (5) seedlings were placed under each screen chamber, under forest canopy and under direct sunlight which served as control treatment. The experimental design used for this study was Completely Randomize Design (CRD). This is because there was only one source of variation whichwas light intensity. The three screen chambers (i.e. 25%, 50% and 75%), under forest canopy (5% light intensity) (Adewunmi *et al.,* 2014; Agbo-Adediran, 2014; Bolanle-Ojo *et al.,* 2014a&b) and under direct sunlight which serves as the control (100% light intensity) constituted thetreatments. The separation of light intensities in the screen chambers were accomplished by the use of wire mesh (single, double and triple layers) that allows the penetration of only certain amount light intensity. The percentage penetration of light intensity entering each screen house was determined with the aid of a photo meter. For biomass estimation, mean height of the seedlings were calculated and one seedling whose height is closest to the mean was selected for destructive sampling at the end of the experiment. The selected seedling from each treatment was carefully uprooted by separating the seedling from the soil, washed and sectioned into root, stem and leaves. Sensitive weighing balance was used to obtain the initial (fresh) weight of leaves, stem and root.After taking the fresh weight, seedling components (leaves, stem and root) were placed in the oven and dried at 70°C until a constant weight was obtained. Since 100% of each component was dried in the oven, the dry weight of each component was taken as their biomass.Seedling total biomass was obtained by summing the biomass of the various components.

Data Collection and Analysis

M. altissima seedlings under each treatment were used to monitor growth characteristics. Growth characteristics such as total height (cm), collar diameter (mm), leaf production and leaf area (cm^3) where taken every two weeks and lasted for the period of twenty-four (24) weeks. Data were collected on biomass accumulation at the end of the experiment. The data were then subjected to one-way analysis of variance to compare the effect of the different treatments on the early growth characteristics of *M. altissima* seedlings. Means were separated using Duncan Multiple Range Test (DMRT) procedure. Results were summarized in tables.

RESULTS AND DISCUSSION

Effect of Light Intensity on the Growth Characteristics of *M. altissima* Seedlings

The result of Analysis of Variance (ANOVA) (Table 1) showed that there was no significant difference ($p>0.05$) in the effect of different light intensities on the height of *M. altissima* seedlings. However, mean values showed that height of the seedlings under 5% light intensity (LI) gave the highest with 16.17 cm while seedlings under 100% LI gave the lowest height with 13.86 cm. There was significant difference ($p\leq0.05$) in collar diameter, leaf production and leaf area of *M. altissima* seedlings. Mean values showed that collar diameter of seedlings under 50% LI was highest with 4.94 mm while the collar diameter of seedlings under 5% LI was lowest with 4.42 mm. Mean separation result revealed that the collar diameter of seedlings under 5% and 100% were not significantly different from each other but significantly different from the collar diameter of seedlings under other light intensities. Seedlings under 25% and 5% LI produced the highest number of leaves with 8 while 100% and 50% LI produced the least with 6 leaves. Mean separation result revealed that the leaves produced by seedlings under 100% and 50% were not significantly different from each other while 25% and 5% LI were not significantly different. Moreover, the leaves of seedlings under 5% LI gave the highest leaf area of 118.52 cm^3 while 100% LI gave the lowest leaf area with 79.11 cm^3. Mean separation result revealed that leaf area of 75% and 50% LI were not significantly different likewise 25% and 5% LI (Table 1).

Table 1: Effect of Light Intensity on the Growth Characteristics of *M. altissima* Seedlings

Light Intensity	Height (cm)	Collar Diameter (mm)	Leaves Production	Leaf Area (cm^3)
100%	13.86±0.45	4.45±0.09[a]	6±0.36[a]	79.11±5.15[a]
75%	15.62±0.60	4.93±0.14[b]	7±0.28[b]	97.45±2.66[b]
50%	15.58±0.90	4.94±0.16[b]	6±0.25[a]	92.39±4.65[b]
25%	15.46±0.94	4.90±0.15[b]	8±0.21[c]	110.89±1.54[c]
5%	16.17±0.88	4.42±0.17[a]	8±0.14[c]	118.52±3.09[c]
Sig	**0.33[ns]**	**0.03***	**0.00***	**0.00***

*ns- not significant (p>0.05) *significant at (p≤0.05), Mean±SE followed by the same superscripts in each column are not significantly different (p>0.05)*

Effect of Light Intensity on the Biomass Accumulated by *M. altissima* Seedlings

Table 2 showed that there was significant difference (p≤0.05) in the effect of light intensities on the leaf dry weight (LDW) of *M. altissima* seedlings. LDW of seedlings subjected to 5% LI gave the highest LDW with 3.10 g while 75% LI gave the lowest with 1.40 g. Mean separation result revealed that the LDW of seedlings under 5% LI is significantly different from LDW of seedlings under other light intensities. There was no significant difference (p>0.05) in the effect of light intensities on the stem dry weight (SDW), root dry weight (RDW) and total dry weight (TDW) of *M. altissima* seedlings. However, the seedlings under 50% LI gave the highest SDW with 2.33 g while 100% LI gave the lowest with 1.74 g. Seedlings under 50% LI gave the highest RDW with 2.60 g while 5% LI gave the lowest with 1.18 g. Moreover, seedlings under 50% gave the highest TDW with 6.72 g while 100% LI gave the lowest TDW with 5.25 g.

Table 2: Effect of Light Intensity on the Biomass Accumulated by*M. altissima* Seedlings

Light Intensity	LDW (g)	SDW (g)	RDW (g)	TDW (g)
100%	1.80±0.17[a]	1.74±0.41	1.71±0.54	5.25±0.99
75%	1.40±0.14[a]	2.16±0.76	2.42±0.72	6.00±1.62
50%	1.80±0.30[a]	2.33±0.89	2.60±1.07	6.72±2.03
25%	2.04±0.14[a]	1.94±0.36	2.09±0.34	6.07±0.78
5%	3.10±0.30[b]	1.83±0.26	1.18±0.28	6.11±1.01
Sig	**0.00***	**0.74[ns]**	**0.14[ns]**	**0.74[ns]**

ns- not significant (p>0.05) *significant at (p≤0.05), Mean±SE followed by the same superscripts in LDW are not significantly different (p>0.05)

DISCUSSION

Seedlings have the ability to utilize certain amount of light intensity to manufacture its own food (Adewunmi*et al.*, 2014). Light is a significant aspect in plant growth and development because of its role in the development of morphological and physiological characteristics of plants. It is therefore important to grow plants under conditions of optimum light intensity that will maximize growth and development. The result obtained showed that there was no significant difference in the effect of light intensity on the height growth of *M. altissima* seedlings. This is in supports the work of Adewunmi *et al*. (2014) who reported no significant difference in the effect of light intensity on the height growth of *E. angolense* seedlings. Furthermore, the result also showed that there was significant difference in the effect of light intensity on the collar diameter, leaf production and leaf area of *M. altissima* seedlings. This is in agreement with the findings of Onyekwelu *et al.* (2013) and Akinyele (2013) who reported significant effect of varying light intensity on the growth characteristics of *Chrysophyllum albidum* and *Buchholzia coriacea* seedlings. The study on the effect of light intensity on plant development is essential for a complete understanding of the processes of dry matter production and its partitioning (Akinyele, 2013). The result obtained on biomass accumulation revealed that the different light intensities had no significant effect. This is in agreement with the work of Adewunmi *et al.* (2014) who reported no significant effect of light intensity on the biomass

accumulated by *E. angolense* seedlings. This is at variance with the work of Bolanle-Ojo*et al*. (2014b) who reported that there was significant effect of light intensity on the biomass accumulated by *Kigelia africana* seedlings. Seedlings of *M. altissima* appeared to perform better in terms of growth under low light conditions resulting in higher plant height, collar diameter, leaf production and leaf area than under full light condition. All light intensities favoured biomass accumulated by *M. altissima* seedlings which shows that the seedlings were able to utilize the varying light intensities to accumulate biomass. Despite this, it would be better to raise the seedlings of *M. altissima* under a reduced light condition due to the higher growth recorded with the seedlings under 5% and 25% light intensities.

CONCLUSION

Accessibility of seedlings of high vigor are vital features suitable in the establishment of tree estate. The result from this study has shown the *M. altissima* seedlings can be raised in the nursery under low light condition. The result revealed that growth characteristics of *M. altissima* seedlings depend on the amount of light intensity received while biomass accumulation do not depend on the amount of light intensity received. Tree seedlings placed under different light intensities that caused changes in growth features might not have any effect on the biomass accumulated.

REFERENCES

Adewunmi, A.O., Bolanle-Ojo, O.T. and Oladejo, A.O. (2014). Seedling Growth Performance of *Entandrophragma angolense* (Welw.) C.DC. as Influence by Different Light Intensities. *Journal of Agriculture, Forestry and the Social Sciences.* 12(2): 197-206

Agbo-Adediran, A.O. (2014). Effect of light intensity and watering regimes on the seedling growth of *Entradrophragma angolense*. M.Sc.Disseratation, Submitted to the Dept. of Forest Resources Management, University of Ibadan, Nigeria. Pp 12-49

Akinyele, A.O. (2013). Sivicultural Requirements of Seedlings of *Buchholzia coriacea* Engler. Lambert Academic Publishing, Germany. 1-185

Bolanle – Ojo, O. T., Afolabi, J.O. and Fapojuwomi, O.A. (2015). Early Growth Performance of *Garcinia kola* Heckel. as Influenced by Different Light Intensities. In: Forest and People: Investing in a Sustainable Future. XIV World Forestry Congress (WFC), Durban, South Africa, 7-11 September 2015.

Bolanle-Ojo, O.T., Ogunade, J.O., Williams, O.A. and Ajekigbe, J.M. (2014a). Biomass Accumulated by *Garcinia kola* Heckel. Seedlings under Different Light Intensities. *Journal of Agriculture, Forestry and the Social Sciences.* 12(2): 159-165

Bolanle – Ojo O.T., Yakubu, F.B., Williams, O.A., Yahaya, D.K. and Asabia, L.O. (2014b). Seedling Growth Performance of *Kigelia africana* (Lam.) Benth. as Influenced by Different Light Intensities. *European Journal of Agriculture and Forestry Research*. Vol.2, No.3, pp.1-13

FAO. (1999):State of the World's Forests, 1999. Third edition. Food and Organization of the United Nations, Rome.

FRIN (2015). Forestry Research Institute of Nigeria, Annual Meteorological Report.

Irvine, F.A.R. (1961). Woody plants of Ghana with Special Reference to their Uses. Oxford Univ. Press London p 146.

IUCN. (2014).International Union for Conservation of Nature 2008 Red list of threatened species.

Leakey, R.R.B. (2004). Physiology of Vegetative Production. In: Burley, J., Evans, J. and Young quist, J.A. (eds) Encyclopaedia of forest sciences. Academic press, London, pp 1655-1668.

Maku, J.O., Gbadamosi, A.E. and Fadoju, O.A. (2014). Germination and Seedling Growth *Mansonia altissima* A. Chev. in Response to Hormonal Treatment. *International Journal of Agriculture and Forestry*. 4(4): 269-274 DOI: 10.5923/j.ijaf.20140404.02

Onyekwelu, J.C., Stimm, B., Mosandl, R. and Olusola, J.A. (2013). Domestication of Socio-Economically Important Forest Food Tree Species: Effects of Light Intensities on Germination and Early Growth of *Chrysophyllum albidum* and *Irvingia gabonensis*. *In: Agricultural development within the rural-urban continuum.*Tropentag, September 17-19, 2013, Stuttgard-Hohenheim.

Rafiqul, H.M., Hossian, M.K., Mpoinddon, M. and Hoque, M.M. (2004). Effect of Inorganic Fertilizers on the Initial Growth Performance of *Anthocephalus chiinesis* (Lam) Seedlings in Nursery. *Journal of Applied science*. 4: 477-485

Siaw, D.E.K.A., Owusu-Prempeh, N., Asare, A., Duodu, C. and Akoto, S.A. (2014). Performance of *Terminalia superba* and *Triplochiton scleroxylon* Seedlings Under Different Forest Canopy. *JENRM*, 1:2, 98-105

Wang, G.G. and Bauerle, W.L. (2006). Effect of Light Intensity on the Growth and Energy Balance of Photosystem II Electron Transport in *Quercusalba* Seedlings. *Ann. For. Sci.* 63: 111-118

Effect of Organic Fertilizers on the Growth Performance of *Entandrophragma angolense* (Welw.) C. DC Seedlings

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ABSTRACT

The study was designed to investigate the effects of application of two sources of organic manure, namely poultry droppings and cow dung manure on the growth of Entandrophragma angolense seedlings. The experimental design was completely randomized design consisting of 7 treatments and replicated 5 times. The treatments were 10, 20 and 30 g (poultry droppings and cow dung) and control (top soil only). 2 kg of soil was used for this experiment. Seedling height, collar diameter, leaf production and biomass accumulation of E. angolense seedlings were determined. The result indicated no significant effect of organic manures on the height, collardiameter and leaf production of the seedlings but there was significant effect of the organic manures on the biomass accumulation. The result thus showed that poultry better enhance the growth and biomass accumulation of E. angonlense seedlings. This can be used in raising this species in the nursery for production of vigorous seedlings. Poultry manure is an organic fertilizer that is readily available which can be collected by the farmers to raise this species.

Keywords: Fertilizer application, tree seedlings, growth enhancement, biomass accumulation

INTRODUCTION

A range of social, economic and environmental goods and services such as food, medicine, wood, and fiber are provided by the forests, thereby playing an important role in local and global development (Adewunmi *et al.*, 2014). Trees have also helped in the stabilization of climate, prevention of erosion and maintenance of water supply. The soil is being protected against radiation and excessive diurnal temperature fluctuations (NEST, 1991). Despite the importance of forests, they are disappearing at a startling rate mostly due to anthropogenic activities (Adeyoju, 2001; Offiong *et al*., 2010). The scarcity of indigenous tropical hardwoods required for export and domestic consumption is increasing in most West African countries as the natural forest is depleted. Over-exploitation, population pressure as well as competition for land by agriculture and other sectors of the economy are major factors affecting forest degradation in the region. Consequently, selective exploitation of the remaining forest resources has reduced the diversity of the available gene pool of important timber species (Ladipo *et al.*,1994).

Entandrophragma angolense has long been widely recognized as an important indigenous tree species which belong to the mahogany family.African mahoganies of the genus *Entandrophragma are* among important timber species harvested in Africa and representover 70% of total export volume from many regions (Jefferson, 2008). The commercial interest in its timber has resulted in extraction of large individuals from the forest throughout its distribution area. In many regions in West Africa, *E .angolense* is considered threatened. It is included in the IUCN Red list as a vulnerable species (Hawthorne, 1998). Successful stand establishment is essential for efficient production of forest trees. Many factors are known to be related to tree growth. Among these factors is soil fertility. There is gap in knowledge concerning the silvicultural requirement of this species (Adewunmi *et al*., 2014). Production of healthy seedlings in the nursery in Nigeria and other developing countries is achieved by the addition of organic manure into nursery soil which has been common practice in recent time for the improvement of soil fertility. Addition of manure has been recognized as effective silvicultural tools for raising healthy forest nursery stock and for hastening growth of trees in the plantation (Fagbenro and Adeola, 1981). Hence, this study will provide information on the response of *E. angolense* seedlings to cow dung and poultry droppings manure which will help in the production of healthy seedlings of this species in the nursery for possible plantation establish in Nigeria.

MATERIALS AND METHODS

Experimental site

The screen house experiment was carried out at the Department of Sustainable Forest Management, Forestry Research Institute of Nigeria (FRIN), Ibadan, Oyo State. FRIN is located on the longitude $07^0$23'18"N to $07^0$23'43"N and latitude $03^0$51'20"E to $03^0$51'43"E. The climate of the study area is the West African monsoon with dry and wet seasons. The dry season is usually from November through March and is characterized by dry cold wind of harmattan. The wet season usually starts from April to October with occasional strong winds and thunderstorms. Mean annual rainfall is about 1548.9 mm, falling within approximately 90 days. The mean maximum temperature is 31.9^0C, minimum 24.2^0C while the mean daily relative humidity is about 71.9% (FRIN, 2015).

Experimental Procedure

The study investigated the effect of cow dung and poultry droppings manure on the growth of *E. angolense* seedlings. The experiment was laid out in a Completely Randomized Design (CRD) with 7 treatments replicated 5 times. A total of 35 seedlings of *E. angolense* were used for this experiment. The treatments are as follows: T1- 10 g of poultry droppings, T2- 10 g of cow dung, T3- 20 g of poultry droppings, T4- 20 g of cow dung, T5- 30 g of poultry droppings, T6- 30 g of cow dung and T7- control (Top soil only). The manure was allowed to decompose for the period of 1 month in 2 kg of forest topsoil before transplanting the seedlings. Five seedlings were placed in each treatment. The seedlings were watered daily and growth variables were assessed every 2 weeks for the period of 4 months.The growth variables were; plant height (cm), collar diameter (mm) and leaf production. Biomass estimation: The selected seedlings from each treatment were carefully uprooted by separating the seedling from the soil, washed and sectioned into root, stem and leaves. Sensitive weighing balance was used to obtain the initial (fresh) weight of leaves, stem and root. After taking the fresh weight, seedling components (leave, stem and root) were taken to the analytical laboratory of the Department of Sustainable Forest Management, FRIN and placed in the oven and dried at 70°C until a constant weight was obtained. Since 100% of each component was dried in the oven, the dry weight of each component was taken as their biomass. Seedling total biomass was then obtained by summing the biomass of the various components.

RESULTS AND DISCUSSION

RESULTS

Physical and Chemical Properties of Soil

Table 1 showed that characteristics of the soil used for the experiment. The soil was moderately acidic (pH = 5.2) sandy loam with organic matter and total N contents of 5.5 and 0.61 g/kg-1 respectively. Soil available P was 3 mg/kg-1 while the exchangeable K, Ca and Mg were 0.2, 3, 0.3 cmol/kg-1 respectively.

Initial properties of the organic manure

Table 2 showed that the poultry droppings was near neutral (pH = 6.75) while cow dung was slightly acid (pH = 6.46). All the nutrient elements were higher in poultry droppings than in cow dung except for Zn that was higher in cow dung.

Table 1: Physical and Chemical Properties of Soil

Soil properties	Measured value	Critical value
pH(1:1 H20)	5.2	
Organic carbon(g/kg-1)	5.5	15.0g/kg-1
Total Nitrogen (g/kg-1)	0.61	1.5g/kg-1
Available P (mg/kg-1)	3	10 -16mg/kg-1
Exchangeable cation (cmol/kg-1)		
Ca	3	
Mg	0.3	
K	0.2	0.2cmol/kg-1
Na	0.3	
Extractible micronutrient (mg/kg-1)		

Mn	94	5 – 100mg/kg-1
Fe	89	5 -200mg/kg-1
Cu	2	1.2 – 2.0mg/kg-1
Zn	8	1 – 5mg/kg-1
Mechanical analysis (g/kg-1)		
Sand	880	
Silt	72	
Clay	48	
Textural class: Sandy loam		

Source: Laboratory Result, 2015

Table 2: Initial properties of the organic manure

Parameters	Cow dung	Poultry dropping
pH(H2O)	6.46	6.75
Organic C (%)	27.7	29.76
Total N (%)	3.47	3.54
Avail P (mg/kg)	1.68	3
K (%)	1	2
Ca (cmol/kg)	21.23	23.26
Mg (cmol/kg)	0.11	0.19
Na (cmol/kg)	32	35
Mn (ppm)	86.5	93.34
Fe (ppm)	70.1	71.52
Cu (ppm)	4.2	14.97
Zn (ppm)	3.28	1.53

Source: Laboratory Result, 2015

Effect of organic fertilizers on the Growth of *E. angolense* Seedlings

The result of ANOVA revealed that there was no significant difference ($p>0.05$) in the effect of cow dung and poultry droppings on the mean height, collar diameter and leaf production of *E. angolense* seedlings (Table 3). However, mean values showed that height of the seedlings grown with T3 was the highest with 15.91 cm while the height growth of the seedlings grown with T2 gave the lowest with 12.52 cm. In case of collar diameter, mean values showed that collar diameter of the seedlings grown with T5 had the highest with 5.73 mm while the collar diameter of the seedlings grown with T7 gave the lowest with 4.89 mm. Moreover, mean values showed that leaves produced by the seedlings grown with T3 and T5 gave the highest with 8 leaves while the leaves produced by seedlings grown with T6 gave the least with 6 leaves (Table 3).

Table 3: Effect of organic fertilizers on the Growth of *E. angolense* Seedlings

Organic Fertilizers	Height (cm)	Collar Diameter (mm)	Leaf Production
T1	13.54	5.54	7
T2	13.84	5.48	7
T3	15.91	5.64	8
T4	14.04	5.32	7
T5	13.55	5.73	8
T6	13.53	5.01	7
T7	12.52	4.89	6
Sig.	**0.39^{ns}**	**0.51^{ns}**	**0.51^{ns}**

ns- not significant (p>0.05)

Effect of organic fertilizers on the Biomass Accumulated by *E. angolense* Seedlings

Table 4 showed that there was significant effect of the organic fertilizers on the biomass accumulated by *E. angolense*seedlings. Mean values showed that seedlings grown with T3 gave the highest leaf dry weight (LDW) with 10.27 g while seedlings grown with T7 gave the least LDW with 4.80 g. Seedlings grown with T3 gave the highest stem dry weight (SDW) with 7.50 g while seedlings grown with T7 gave the least SDW with 2.87 g. T5 gave the highest root dry weight (RDW) with 7.10 g while T7 gave the least with 2.90 g. Seedlings grown with T3 gave the highest total dry weight (TDW) with 24.13 g while seedlings grown with T7 gave the least with 10.57 g (Table 4). The order of performance of the organic manures was poultry droppings > cow dung > control and these were reflected in the overall means.

Table 4: Effect of organic fertilizers on the Biomass Accumulated by *E. angolense* Seedlings

Organic fertilizers	LDW	SDW	RDW	TDW
T1	7.63 ± 1.10^{bc}	5.10 ± 0.75^{a}	5.43 ± 0.75^{abc}	18.17 ± 1.44^{bc}
T2	6.53 ± 0.75^{ab}	4.70 ± 0.35^{a}	4.60 ± 0.40^{abc}	15.83 ± 1.26^{ab}
T3	10.27 ± 0.74^{d}	7.60 ± 0.85^{b}	6.27 ± 0.62^{bc}	24.13 ± 2.15^{c}
T4	7.47 ± 0.58^{bc}	4.93 ± 1.17^{a}	4.17 ± 0.69^{ab}	16.57 ± 2.44^{ab}
T5	9.47 ± 0.69^{cd}	4.83 ± 0.78^{a}	7.10 ± 1.41^{c}	21.40 ± 2.77^{bc}
T6	8.13 ± 0.19^{bcd}	5.03 ± 0.35^{a}	5.20 ± 0.21^{abc}	18.37 ± 0.48^{bc}
T7	4.80 ± 0.58^{a}	2.87 ± 0.82^{a}	$2.90\pm.80^{a}$	10.57 ± 2.15^{a}
Sig. (DMRT)	**0.00***	**0.03***	**0.04***	**0.01***

Means±SE with different alphabet in columns are significantly different from each other ($p\leq0.05$)

Effect of organic fertilizers on the Biomass Accumulated by *E. angolense* Seedlings

Table 4 showed that there was significant effect of the organic fertilizers on the biomass accumulated by *E. angolense* seedlings. Mean values showed that seedlings grown with T3 gave the highest leaf dry weight (LDW) with 10.27 g while seedlings grown with T7 gave the least LDW with 4.80 g. Seedlings grown with T3 gave the highest stem dry weight (SDW) with 7.50 g while seedlings grown with T7 gave the least SDW with 2.87 g. T5 gave the highest root dry weight (RDW) with 7.10 g while T7 gave the least with 2.90 g. Seedlings grown with T3 gave the highest total dry weight (TDW) with 24.13 g while seedlings grown with T7 gave the least with 10.57 g (Table 4). The order of performance of the organic manures was poultry droppings > cow dung > control and these were reflected in the overall means.

DISCUSSION

Fertilizer requirements of species differ, and as such, effort must be made to identify the appropriate fertilizer preference of any species. The moderate acidity and low contents of organic matter, total N, available p and exchangeable K of the soil have inherent nutrient status of the tropics that would therefore benefit from fertilizer application in order to enhance the growth of seedlings (Adegun and Ayodele, 2015; Manan and Mason, 2013). The soil was deficient in organic matter, total N and available P based on critical levels of organic matter, total N and available P for soils in south-western Nigeria. The higher content of nutrient elements in poultry manure than cow dung manure might be due to the higher nutrient status of the feeds. The result on the height, collar diameter and leaf production of *E. angolense* seedlings in this study is in correlation with the findings of Okunomo (2010) who reported that the organic manures applied did not significantly affect the collar diameter and leaves production of *Tetrapluera tetraptera* seedlings. The result on the biomass accumulated by *E. angolense* seedlings in this study is in correlation with Imoro*et al.* (2012) who reported that the organic fertilizers applied significantly affected the biomass accumulated by*Moringa oleifera* seedlings. Poultry manure performed better than cow dung in improving the growth of *E. angolense* seedlings in terms of height, collar diameter, leaf production and biomass accumulation. This could be traced to the higher nutrient content (N, P, K, Ca and Mg) present in poultry manure which increased the soil nutrient and consequently improving nutrient and water uptake in the plants this is in correlation with the findings of Moyin-Jesu and Adeofun (2008) who reported that the nutrient content of poultry was higher than that of other sources of organic manure.

CONCLUSION

This study has proven that the addition of poultry manure can better enhance the growth of *E. angolense* seedlings than cow dung in the nursery. Addition of 20g of poultry manure to 2 kg of soil performed best in improving the growth of *E. angolense* seedlings. This can be used in raising this species in the nursery for production of vigorous seedlings. Poultry manure is an organic fertilizer that is readily available which can be collected by the farmers to raise this species.

REFERENCES

Adegun, M.K. and Ayodele, O.J. (2015). Growth and Yield of *Moringa oleifera* as Influenced by Spacing and Organic Manures in South-Western Nigeria. *International Journal of Agronomy and Agricultural Research (IJAAR)*. 6(6): 30-37

Adewunmi, A.O., Bolanle – Ojo, O.T. and Oladejo, A.O. (2014). Seedling Growth Performance of *Entandrophragma angolense* as Influenced by Different Light Intensities. *Journal of Agriculture, Forestry and Social Sciences (JOFASS)*. 12(2): 197-206

Adeyoju, S.K. (2001). Forestry for National development: a critique of the Nigeria situation. Proceedings of the 27th Annual Conference of the Forestry Association of Nigeria Abuja FCT (eds. Popola, L. and Abu, J.E.), 55-68.

FRIN (2015). Forestry Research Institute of Nigeria, Annual Meteorological Report.

Hawthorne, W. (1998). *Entandrophragma angolense*. In: IUCN 2012. IUCN Red list of Threatened Species. Version 2012.2. www.iucnredlist.org {Retrieved 11/2/2013}.

Imoro, A. W. M., Sackey, I. and Abubakari, A.H. (2012). Preliminary Study on the Effect of Two Different Sources of Organic Manures on the Growth Performance of *Moringa oleifera* Seedlings. Journal of Biology, Agriculture and Healthcare. 2(10): 147-158

Jefferson S.H. (2008). Seed and seedling survival of African mahogany (Entandrophragma spp) in the Central African Republic. *Forest Ecology and Management*.292-299

Ladipo, D.O., Britwum, S.P.K., Tchoundjeu, Z., Oni, O. and Leakey, R.R.B. (1994). Genetic Improvement of West African Tree Species: past and present. In: Leakey, R.R.B., Newton, A.C., (eds). Tropical trees: the potential for domestication and the rebuilding of forest resources.

Manan S and Mason S (2013.) Poultry manure and inorganic fertilizer to improve pearl millet yield. *Nigeria Academic Journals.* 7, 162-169.

Moyin-Jesu, E.I. and Adeofun, C.O. (2008). Comparative Evaluation of Different Organic Fertilizers on the Soil Fertility, Leaf Mineral Composition and Growth of Bitter Kola Seedlings. Emir. J. Food Agric. 20(1):31-45

NEST, (1991). Nigeria's Threatened Environment. Publication of the Environment study/Action Team (NEST), Ibadan, Nigeria. 18

Offiong, M.O., Udofia, S.I., Owoh, P.W. and Ekpenyong, G.O. (2010). Effects of fertilizer on the early growth of *Tetrapleura tetraptera* (Del). *Nigeria Journal of Agriculture, Food and Environment.* 6(1&2): 53-59

Okunomo, K. (2010). Effect of Organic Manure on Seedling Growth and Development of *Tetrapluera tetraptera*. *Nigerian Journal of Research and Production*. 16(1): 1-7

Effect of Wood Char on the Growth of *Mansonia altissima* Seedlings A. Chev.

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ABSTRACT

The study investigated the effect of wood char on the growth of Mansonia altissima seedlings. The experimental design was completely randomized design consisting 6 treatments and replicated 7 times. The treatments were 10, 20, 30, 40, 50 g of wood char and control (top soil only). 2 kg of soil was used for this experiment. Seedling height, collar diameter, leaf production and biomass accumulation of M. altissima seedlings were determined. The result indicated no significant effect of wood char on the growth characteristics measured but there was significant effect of the wood char on the biomass accumulation of M. altissima seedlings. It can be inferred that wood char has no substantial effect on the growth of M. altissima. This might be due to the slow decomposition rate of the char. The study has shown that production and application of wood char in the nursery for raising seedlings is not viable. It could better be used on the field.

Keywords: Seedlings, soil improver, biochar, growth, biomass accumulation

INTRODUCTION

In recent years, there have been increasing attention and awareness on the utilization of biochar as soil amendment. Wood char is a carbon (C) rich product derived from the pyrolysis of organic material at temperature between 400^{o}C-700^{o}C (Lehmann and Joseph, 2009). It is a by-product of bio-energy production using pyrolysis. There is intense interest in using wood char as a means to sequester carbon in soils as a tool for offsetting anthropogenic carbon dioxide (CO_2) emissions, and as a soil amendment (Lehmann and Joseph, 2009). With ideal feedstock, such as woody biomass, the resulting material is highly aromatic with carbon concentrations of 70 to 80% and unique adsorption properties (high affinity for nutrients) and stability (high persistence) (Lehmann *et al*., 2006).

Wood char is a high surface area, highly porous, variable charge organic material that has the potential to increase soil water-holding capacity, cation exchange capacity (CEC), surface adsorption capacity and base saturation when added to soil (Glaser *et al*., 2002; Liang *et al*., 2006).The surface area, porosity, nutrient content and charge density all change in relation to the temperature of biochar formation (Gundale and DeLuca, 2006). Biochar additions to soil also have the potential to alter soil microbial populations and to shift functional groups (Pietikäinen *et al*., 2000) and have the potential to reduce soil bulk density (Gundale and DeLuca *et al*., 2006).

On a global scale, world forests are declining at an extreme alarming rate due to increase in human population growth, which has doubled in the last 50 years. From 1990 to 2005, the world lost 30% of its total area of forested land, an average decrease of some 0.2% per year (FAO, 2007). Natural forest is being depleted and over-exploited due to the increasing demand for indigenous tropical hardwoods for export and domestic consumption (Ladipo *et al*., 1994). Consequently, deforestation has a devastating impact on the environment due to the inability of the atmosphere to mop up excessive release of carbon dioxide and other greenhouse gases.

Mansonia altissima belongs to the family *Sterculiaceae* (Irvine, 1961). It is a deciduous forest species growing up to 37 m in height and girth of 2.5 m, bearing a dense canopy and deciduous in dry season (Irvine, 1961).*M. altissima*has been described as vulnerable according to the IUCN Red list of threatened species (IUCN, 2014); it therefore requires urgent conservation attention. In an effort to regenerate the exploited stands starting by raising seedlings of *M. altissima*, there is a need to focus on methods that will enhance its sustainable speedy growth.
Conservation effort to promote rapid propagation of this economic species is desirable. This will reverse the current trend of the species to over-exploitation.Inorganic fertilizers have been used by researchers particularly in the nursery to raise seedlings; due to it

high cost of procurement, there is a need for alternative source of soil conditioner nutrient for rapid growth and development of seedlings at nursery stage.

The productivities of soil depend upon the supply of organic materials. Wood char can be used to improve the physical, biological and chemical condition of soil as a source of nitrogen and a carrier of fertilizer. The application of charcoal can lower the pH of acidic soils and affect microbial population and their activities in the soil (Davies *et al.*, 2007). Information on how wood char affects the growth performance of *M. altissima* seedlings in the nursery will help to know if wood char can be used as substitute for conventional organic manure.

MATERIALS AND METHODS

Experimental Site

The screen house experiment was carried out at the Department of Sustainable Forest Management, Forestry Research Institute of Nigeria (FRIN), Ibadan, Oyo State. FRIN is located on the longitude $07^0$23'18"N to $07^0$23'43"N and latitude $03^0$51'20"E to $03^0$51'43"E. The climate of the study area is the West African monsoon with dry and wet seasons. The dry season is usually from November through March and is characterized by dry cold wind of harmattan. The wet season usually starts from April to October with occasional strong winds and thunderstorms. Mean annual rainfall is about 1548.9 mm, falling within approximately 90 days. The mean maximum temperature is 31.9^0C, minimum 24.2^0C while the mean daily relative humidity is about 71.9% (FRIN, 2015).

Experimental Procedure

Wood char of *Triplochyton sceleroxylon* (Obeche) was collected from the Department of Wood and Paper Technology, Federal College of Forestry, Jericho-Ibadan.A total of forty-two (42) seedlings of *M. altissima*with uniform heights were selected for this experiment. 2 kg of top soil was used for each seedling. The experiment was laid out in Completely Randomized Design (CRD) with each treatment replicated seven (7) times. Different quantities of wood char consisted the treatments namely; 10 g, 20 g, 30 g, 40 g, 50 g of wood char and control (top soil only). The different quantities of wood char were added to the soil in the polythene pots and allowed to decompose for the period of 4 weeks before the seedlings were transplanted. For biomass estimation, mean height of the seedlings were calculated and one seedling whose height is closest to the mean was selected for destructive sampling at the end of the experiment. The selected seedling from each treatment was carefully uprooted by separating the seedling from the soil, washed and sectioned into root, stem and leaves. Sensitive weighing balance was used to obtain the initial (fresh) weight of leaves, stem and root.After taking the fresh weight, seedling components (leaves, stem and root) were placed in the oven and dried at 70°C until a constant weight was obtained. Since 100% of each component was dried in the oven, the dry weight of each component was taken as their biomass.Seedling total biomass was obtained by summing the biomass of the various components.

Data Collection and Analysis

M. altissima seedlings under each treatment were used to monitor growth characteristics. Growth characteristics such as total height (cm), collar diameter (mm) and leaf production where taken every two weeks and lasted for the period of twelve (12) weeks. The data (early growth parameters) were then subjected to one-way analysis of variance to compare the effect of the different treatments on the early growth characteristics of *M. altissima* seedlings. Means were separated using Duncan Multiple Range Test (DMRT) procedure. Results were summarized in tables.

RESULTS AND DISCUSSION

RESULTS

Chemical Properties of Soil

Table 1 showed that characteristics of the soil used for the experiment. The soil was slightly acidic (pH = 6.36). Total nitrogen was very low (0.96 g/kg) and carbon content was 2.98%. Exchangeable cations were above the critical value. Extractible micronutrients were low.

Table 1: Chemical Properties of Soil

Soil Properties	Measured Value
pH	6.36
Nitrogen g/kg	0.98
Ca (Cmol/kg)	1.04
Mg (Cmol/kg)	1.15
Na(Cmol/kg)	0.83
K (Cmol/kg)	0.75
C (%)	2.98
P (Mg/kg)	1.68
Mn (Mg/kg)	1.98
Fe (Mg/kg)	3.15
Zn (Mg/kg)	2.04
Cu (Mg/kg)	1.89

Source: Laboratory Result, 2015

Chemical Analysis of Wood Char

Table 2 showed that the wood char was almost neutral. The density of the char was 0.62 g/cm^3 with a very high carbon content of 79.06 g/kg that above the critical value. Total nitrogen content (2.15 g/kg) was more than the critical value. Exchangeable cations were above the critical value.

Table 2: Chemical Analysis of Wood Char

Parameter	Wood Char
PH	7.08
Density (g/cm3)	0.62
Moisture Content %	6.97
Carbon g/kg	79.06
Sulphur Mg/kg	1.03
Nitrogen g/kg	2.15
Ash%	3.28
Ca (Cmol/kg)	0.352
K (Cmol/kg)	0.748
Mg (Cmol/kg)	0.296
Na (Cmol/kg)	0.168
P (mg/kg)	0.35
Mn (mg/kg)	28.2
G.Energy Kcal/g	2.068

Source: Laboratory Result, 2015

Effect of Wood Char on the Growth of *M. altissima* Seedlings

Analysis of Variance (ANOVA) indicated that there were no significant differences ($p>0.05$)in the height, collar diameter and leaf production of *M. altissima* seedlings subjected to different quantities of wood char (Table 3). However, seedlings grown with 40 g of wood char gave the highest mean (13.31 cm) while seedlings grown with 10 g of wood char gave the least growth in mean height (12.42 cm). For collar diameter, seedlings grown with 20 g of woodchar and control gave the highest mean value of collar diameter

(3.06 mm) while seedlings grown with 10 g and 30 g of wood char gave the least growth in collar diameter (2.73 mm). For leaf production, seedlings grown with 20g of wood char gave the highest mean value of leaf production (8 leaves) while seedlings grown with the other treatments produced seven (7) leaves of mean value which was the least (Table 3).

Table 3: Effect of Wood Char on the Growth of *M. altissima* Seedlings

Wood Char	Height (cm)	Collar Diameter (mm)	Leaf Production
10 g	12.42±0.81	2.73±0.16	7±0.32
20 g	13.03±0.41	3.06±0.11	8±0.24
30 g	12.70±1.34	2.73±0.29	7±0.67
40 g	13.31±0.85	3.05±0.18	7±0.29
50 g	12.62±0.81	2.92±0.15	7±0.43
Control	13.28±0.64	3.06±0.09	7±0.22
Sig	**0.97^{ns}**	**0.53^{ns}**	**0.62^{ns}**

ns- not significant (p>0.05)

Effect of Wood Char on the Biomass Accumulated by *M. altissima* Seedlings

ANOVA indicated that there were significant differences (p≤0.05) in the leaf dry weight (LDW), stem dry weight (SDW), root dry weight (RDW) and total dry weight (TDW) of *M. altissima* seedlings subjected to different quantities of wood char (Table 1). Seedlings grown with control gave the highest mean value of LDW (2.30 g) while seedlings grown with 50 g of wood char gave the least growth in mean LDW (0.40 g). Seedlings grown with control gave the highest mean value of SDW (1.90 g) while seedlings grown with 20 g of wood char gave the least SDW (0.37 g). Seedlings grown with control gave the highest mean value of RDW (0.90 g) while seedlings grown with 40 g of wood char gave the least RDW (0.10 g). Seedlings grown with control gave the highest TDW (5.13 g) while seedlings grown with 50 g of wood char gave the least TDW (1.00 g). Mean separation revealed that the biomass accumulated by seedlings grown with control was significantly different from the biomass accumulated by the seedlings grown with other treatments.

Table 4: Effect of Wood Char on the Biomass Accumulated by *M. altissima* Seedlings

Wood Char	LDW (g)	SDW (g)	RDW (g)	TDW (g)
10 g	0.80±0.15^{bc}	0.50±0.06^{b}	0.20±0.10^{b}	1.50±0.10^{bc}
20 g	0.90±0.21^{bc}	0.37±0.15^{b}	0.23±0.13^{b}	1.50±0.40^{bc}
30 g	1.63±0.19^{ab}	0.83±0.03^{b}	0.50±0.06^{ab}	2.29±0.17^{b}
40 g	1.10±0.29^{bc}	0.50±0.06^{b}	0.10±0.00^{b}	1.70±0.32^{bc}
50 g	0.40±0.06^{c}	0.40±0.15^{b}	0.20±0.10^{b}	1.00±0.26^{c}
Control	2.33±0.46^{a}	1.90±0.25^{a}	0.90±0.31^{a}	5.13±0.97^{a}
Sig (DRMT)	**0.00***	**0.00***	**0.02***	**0.00***

**significant at (p≤0.05), Mean±SE followed by the same superscripts in each column are not significantly different (p>0.05)*

DISCUSSION

There were no significant differences in the height, collar diameter and leaf production of *M. altissima* among different levels of wood char used. It has been established that wood char can, but does not always increase soil productivity (Schmidt and Noack, 2000; Jeffery *et al*., 2011; Reyes *et al.*, 2015).Positive plant growth and nutrient content responses to wood char are commonly observed in association with fertilizer application, while neutral or even negative plantgrowth responses have been observed succeeding wood char only amendments. Much greateryields in plant growth are observed with fertilizer additions plus wood char, as opposed tofertilizer additions alone (Yamato *et al*., 2006; Gundale and DeLuca 2007;Asai*et al.*, 2009; Blackwell *et al*., 2009).

CONCLUSION

Since, there was no significant difference among the treatments used with respect to the parameters assessed; it can be inferred that wood char has no substantial effect on the growth of *M. altissima*. This might be due to the slow decomposition rate of the char.The study has shown that production and application of wood char in the nursery for raising seedlings is not viable. It could better be used on the field.

REFERENCES

Asai, H., Samson, B. K., Stephan, H. M., Songyikhangsuthor, K., Homma, K., Kiyono, Y., Inoue, Y., Shiraiwa, T., and Horie, T. (2009): Biochar amendment techniques for upland rice production in northern Laos. *Field Crops Research 111:81-84.*

Blackwell, P., Reithmuller, G and Collins, M. (2009): Biochar applications to soil. In Biochar for Environmental Management: Science and Technology Eds. J. Lehmann and S. Joseph. Earthscan, London; Sterling, VA, pp. 207-226.

Davies, E. O., Molina enough nutrient needed for plant. *America Journal of soil science lo (16): 173 158*

FAO (2007): State of the World's Forests 2005. FAO, Rome, Italy.

FRIN (2015). Forestry Research Institute of Nigeria, Annual Meteorological Report.

Glaser, B. Lehmann, J. and Zech, W. (2002). Ameliorating Physical and Chemical Properties of Highly Weathered Soils in the Tropics with Charcoal – A Review. *Biol. Fertil. Soils*. 35: 219-230

Gundale, M. J. and DeLuca, T. H. (2006): Temperature and source material influence ecological attributes of ponderosa pine and Douglas-fir charcoal. *Forest Ecology and Management. 231:86-93.*

Irvine, F.A.R. (1961). Woody plants of Ghana with Special Reference to their Uses. Oxford Univ. Press London p 146.

Lehmann, J., Gaunt, J. and Rondon, M. (2006). 'Bio-char Sequestration in Terrestrial Ecosystems - A Review', *Mitigation and Adaptation Strategies for Global Change*, 11: 403-427

Lehmann, J. and Joseph, S. (2009). Biochar for Environmental Management: An Introduction. ES_BEM 16(2): 1-12

Liang, B. J., Lehman, D., Solomon, J., Kinyangi, J., Grossman B.O., Meill, J.O., Skjermastad, J. P and Neves, E.G (2006): Black carbon increases caution Exchange capacity in soil. *Soil science society of America Journal 70:1719-1730.*

Pietikainen, J., Kiikkila, O. and Fritze, H. (2000). Charcoal as a Habitat for Microbes and its Effect on the Microbial Community of the Underlying Humus. OIKOS 89: 231-242

Reyes, O., Kaal, J., Aran, D., Gago, R., Bernal, J., García-Duro, J. and Basanta, M. (2015): The effect of ash and black carbon (biochar) on germination of different tree species. *Fire Ecology 11(1): 119–133*

Yamato, M., Okimori, Y., Wibowo, I. F., Anshori, S., and Ogawa, M. (2006): Effects of the application of charred bark of Acacia mangium on the yield of maize, cowpea and peanut, and soil chemical properties in South Sumatra, *Indonesia. Soil Science and Plant Nutrition 52:489 – 495.*

Development of height-dbh relationship for *Gmelina arborea* (Roxb.) in Ibadan, Nigeria

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ABSTRACT

Tree height-diameter relationship can be used as an important input component in forest growth and yield models, and description of stand dynamics. Five non-linear growth functions were fitted to tree height-diameter data of Gmelina arborea stands planted in 1988. The data consisted of three sets: 2006, 2010 and 2015 on total tree height and diameter at breast height (dbh). According to the model statistics, the five growth functions fitted the data equally well, but resulted in different asymptote estimates. Modified exponential fit was observed to give the best fit for the three data sets based on least square error, Akaike information criterion (AIC), coefficient of determination and significance. The models are: $Ht = 2.71e^{(-1.16/dbh)}$ *(R^2 = 94.74%, AIC = 502.33),* $Ht = 2.95e^{(-1.36/dbh)}$ *(R^2 = 77.53%, AIC = 718.83) and* $Ht = 3.07e^{(-1.47/dbh)}$ *(R^2 = 66.21%, AIC = 721.36) for 2006, 2010 and 2015 data sets. The predicted values follow the same nonlinear pattern and formed close to the line of best fit without much outlier. The result of this study revealed that the ability of dbh in determining height is not strong enough based on the model's goodness of fit and the model's ability for predictive purposes. This useful information can help forest researchers and managers to select and apply the appropriate models.*

Keywords: Nonlinear model, diameter at breast height, total height, *Gmelina arborea*, forest management

INTRODUCTION

Tropical rainforests are the most varied natural environments to be found on the earth, perhaps the most inspiring and popular. These forests, with their large trees and extraordinary flora and fauna constitute the planet's richest habitats, and one of our most precious natural resources (Longman and Jenik, 2000). Like all tropical rainforests, the Nigerian rainforest is characterized by high species diversity and morphological uniformity of the constituent species. The forest contains trees from a wide range of ages and size classes. Hence, its management requires more precise tools or technique in achieving sustainable forest management.

Measurements of tree heights and diameters are essential in forest assessment, modeling and management. Tree heights are used for estimating timber volume, site index and other important variables related to forest growth and yield, succession and carbon budget models (Peng, *et al* 2001). Considering that the diameter at breast height (dbh) can be more accurately obtained, and at lower cost than total tree height, only a sub-sample of heights is usually measured in the field. Height–diameter equations are then used to predict the heights of the remaining trees, thus reducing the cost of data acquisition. For these reasons, developing suitable height–diameter models may be considered one of the most important elements in forest design and monitoring.

The development of simple and accurate height–diameter models, based on easily obtainable tree and stand characteristics, is a common precursor to using inventory and sample plot data to calculate volume and other stand attributes. A number of height–diameter equations have been developed using only dbh as the predictor variable for estimating total height (e.g., Huang *et al*., 1992; Moore *et al*., 1996; Zhang, 1997; Peng, 1999; Fang and Bailey, 1998; Fekedulengn *et al*., 1999; Jayaraman and Zakrzewski, 2001; Robinson and Wykoff, 2004). However, the relation between the diameter of a tree and its height varies among stands (Calama and Montero, 2004) and depends on the growing environment and stand conditions (Sharma and Zhang, 2004). For a particular height, trees that grow in high density stands will have smaller diameters than those growing in less dense stands, because of greater competition among individuals (Lopez Sanchez *et al*., 2003; Calama and Montero, 2004). The height–diameter relationship is also not constant over time even within the same stand (Curtis, 1967). These factors indicate that additional predictor variables are required to

develop generalized height–diameter models in order to avoid having to establish individual height–diameter relationships for every stand (Temesgen and Gadow, 2004).

The diversity observed in modeling approaches was easily dwarfed by the multiplicity in model forms developed. Numerous linear and nonlinear models have been applied in the quest to produce accurate height–diameter relationships. Candidate functions were often based on their mathematical features (e.g., demonstrating appropriate sigmoidal shape, possessing a sufficient number of parameters to achieve flexibility without compromising parsimony), and the possible biological interpretation of model parameters (Peng *et al*., 2001). Biologically reasonable models generally produced more accurate predictions beyond the range of data used in model fitting (Fekedulengn *et al.*, 1999).

Gmelina arborea timber is a fast growing deciduous tree, occurring in most part of the country as a plantation species. It is reasonably strong for its weight. It is used in constructions, furniture, carriages, sports, musical instruments and artificial limbs. Once seasoned, it is a very steady timber and moderately resistant to decay and ranges from very resistant to moderately resistant to termites. Its timber is highly esteemed for door and window panels, joinery and furniture especially for drawers, wardrobes, cupboards, kitchen and camp furniture, and musical instruments because of its lightweight, stability and durability. It is also used for bentwood articles. In boat building it is used for decking and for oars (Anonymous, 2002). Hence, its choice as plantation species that are mostly sort for by loggers either legally or illegally. Therefore, the objective of this study is to develop and compare selected nonlinear models fitted for *G. arborea* tree height–diameter relationship in the study area for sustainable management.

METHODOLOGY

Study Area

The study was carried out on *Gmilina arborea* plantation that was established in 1988 at Forestry Research Institute of Nigeria, Ibadan, Oyo state, Nigeria. It falls within the rainforest zone of Nigeria and lies between latitude 7^0 20'N and longitude 3^0 56'E with an altitude of 150m above sea level. The study site is under the management of Forestry Research Institute of Nigeria (FRIN). It has a total size of 0.85ha in which total enumeration on the diameter at breast height (dbh) and total height have been carried out. Three sets of data on the PSP were used for this study. These were the 2006, 2010 and 2015 data sets.

Basal Area Estimation

The Basal Area (BA) of individual trees was estimated using the formula in equation 1 (Husch *et al*, 2003)

$$BA = \frac{\pi}{4} D^2 \quad \text{.....1}$$

Where BA = Basal area (m^2), D = dbh (cm).

Slenderness coefficient (SLC) Estimation

$$SLC = \frac{THT}{Dbh}$$

Where THT = Total height

Data analysis

The data collected were analyzed using a nonlinear regression model (Philip, 1994) of the form:

$$\phi_t = f(t_i, \beta) + \varepsilon_i \qquad i = 1, 2, ..., n, \quad \text{..... (2)}$$

Where ϕ is the response variable (height), t is the independent variable (dbh), β is the vector of parameter β_j to be estimated i.e. $(\beta_1, \beta_2, ..., \beta_k)$, ε_i is a random error term, k is the number of unknown parameters and n is the number of the observation. The estimators of β_j's were obtained by minimizing the sum of squares error (SS_{err}) function as below

$$SS_{err} = \sum_{i=1}^{n} [\phi_i - f(t_i, \beta)]^2 \quad \text{..... (3)}$$

Under the assumption that ε_i are normal and independent with mean zero and common variance σ^2. Since ϕ_i and t_i are fixed observations, the sum of square residual is a function of β. Least square estimates of β are values which when substituted into equation 3 made SS_{err} a minimum. These were obtained by differentiating equation 3 with respect to each parameter and setting the result to zero. This provides the k normal equations that must be solved for $\hat{\beta}$. These normal equations take the form

$$\sum_{i=1}^{n} \{\phi_i - f(t_i, \beta)\} \left[\frac{\partial f(t_i, \beta)}{\partial \beta_j} \right]_{\theta = \hat{\theta}} = 0 \quad \text{..... (4)}$$

For j = 1,2,……..,k. when the model is nonlinear in the parameters so are the normal equations, consequently, for the nonlinear models considered above, it is impossible to obtain a closed form solution to the least squares estimate of the parameters by solving the k normal equations described in equation 4. Hence an iterative method was employed to minimize the SS_{err}. The NLIN (nonlinear regression) procedure in SAS (1992) was used to fit the models to the data and estimate the parameters. The quantity in the square bracket is the partial derivative of F(t,β) wrt θ with all the θ replaced by the corresponding θ. e.g. $\beta_1 = \beta_1$, $\beta_2 = \beta_2$, etc.

Fitting of the Models

Five non-linear models were fitted using curve expert for the height–diameter relationship and ranked according to their best of fit using the correlation coefficient, least square error and significance at 5% level of probability.

The models are:

1. Modified Exponential (Khamis, and Ismail, 2004): Y = $a * e^{(b/x)}$
2. Exponential Association (Tsoularis, and Wallace, 2002): Y = $a(1 - \exp(-bx)$
3. Saturation Growth-Rate (Ismail *et al*, 2003): Y = $\frac{ax}{(b + x)}$
4. Modified Geometric Fit (Jaafar, 1999): Y = $a * x^{(b/x)}$
5. Hyperbolic Fit (Philip, 1994): Y = $a + b/x$

Where: Y = Height (m)
X = Dbh (cm)
a & b = model parameters

The model predictions functions for each year of assessment were compared using the root mean square errors and biases/residuals of stand diameter class. The absolute root mean square error (RMSE) was calculated as:

$$\text{RMSE} = \sqrt{\sum_{i=1}^{n} (Vi - \lambda i)^2} / n \quad \text{..... 5}$$

Where n = Number of sample stands

Vi = Diameter/height class of growing stock in stand i

λi = The diameter/height of stand i estimated from the predicted distribution.

The bias of the predictions was calculated as

$$\text{Bias} = \sum_{i=1}^{n} (Vi - \lambda i)/n \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 6$$

RESULTS AND DISCUSSION

The frequencies of the selected trees are 932, 928 and 917 for year 2006, 2010 and 2015 respectively (Table 1). An observation of downward trend in the number of stems per hectare in the plot between 2006 and 2015 was similar to the observation of Oguntala (1981). In his observation of tree population in a permanent sample plot in Gambari forest reserve, Nigeria, he reported that there was consistent decline in the number of trees per hectare for a period of 22 years. This decline in the number of stems per hectares may have been through natural mortality since exploitation and other forms of human disturbance have been strictly prohibited in the plot. Basal area per hectare throughout this period of assessment followed the same trend with the number of stems per hectare. This can be explained by the fact that basal area per hectare is computed from number of trees per hectare and the dbh of the standing trees. Meanwhile, the values of slenderness coefficient obtained for all year of assessment were moderate. The slenderness coefficient values obtained from the analysis of the data were classified into three categories as suggested by Navratil, *et al* (1994) as stated below:

SLC values > 99 = High slenderness coefficient

70 < SLC > 99 = Moderate slenderness coefficient

SLC < 70 = Low slenderness coefficient

Adjudging the result of this study with above classification, all the tree species have low slenderness coefficient (i.e SLC < 70). The value ranges from 36.17 to 142.86, 37.50 to 140 and 36 to 138.60 for 2006, 2010 and 2015 respectively. This implies that all the tree species are not prone to wind throw. Therefore, they all have good standing and vigor. In the same vein, the result of the basal area shows that the trees have high basal areas correlated to the tree enspacement. dbh and height are functions of basal area and volume (Husch *et al*, 2003). As a result of this, values obtained for the dbh and height can be use to project the corresponding tree volume.

Table 1: Summary statistics of growth variables

Years of assessment	Variables	No of trees/ha	Mean	Maximum	Minimum	Standard deviation
2006	dbh (cm)	1,109	28.36	53.00	10.00	9.91
	Height (m)		17.46	26.00	5.00	4.06
	Basal Area (m^2/ha)		20.19	58.50	3.50	0.05
	SLC		65.91	142.86	36.17	19.70
2010	dbh (cm)	1,104	29.01	54.00	10.00	10.08
	Height (m)		18.06	27.00	5.00	4.25

	Basal Area (m^2/ha)		25.80	70.12	4.30	0.05
	SLC		66.40	140.00	37.50	19.33
2015	dbh (cm)	1,084	30.02	54.20	11.00	10.03
	Height (m)		18.54	28.00	5.00	4.36
	Basal Area (m^2/ha)		26.70	72.62	4.81	0.05
	SLC		68.55	138.16	36.00	19.17

Based on the result in table 2, it was observed that the modified exponential model is the best for the height-diameter relationship as 94.74%, 77.53% and 66.21% obtained as the coefficient of determination in the three cases considered. This revealed that 94.74%, 77.53% and 66.21% variation in height were explained by the diameter. Also, the curve was best captured by the modified exponential fit in the three cases considered (fig 1, 2 & 3). The predicted values follow the same nonlinear pattern and formed close to the line of best fit without much outlier. The modified exponential fit also yielded the minimum root mean square error which is an indication that the estimator is efficient compared with other growth curves used in the study. Gregoire *et al*. (1995) pointed out that the determination of fixed and random effects parameters in a model is a flexible decision subject to debate. Pinheiro and Bates (1998) suggest that all parameters in the model should first be considered mixed if convergence is possible. Fang and Bailey (2001) suggest that parameters with the high variability and less overlap in confidence intervals obtained by fitting at each individual plot separately should be considered mixed if the convergence is not achieved when considering all the parameters as mixed. Therefore, the result of this study revealed that the ability of dbh in determining height is not strong enough based on the model's goodness of fit and the model's ability for predictive purposes; hence, as a form of correcting this in the future, we shall include other independent variables like Age, soil fertility, basal area, crown area etc so as to check their effects in determining height.

Table 2: Summary of the fitted models ranked according to their suitability

Year of assessment	Name of the model	R^2 (%)	A	b	RMSE	AIC
2006	Modified exponential	94.74	2.71	-1.16	3.2607	502.33
	Exponential association	56.07	2.30	5.34	3.2619	631.00
	Saturation growth-rate	66.01	3.07	2.05	3.2661	582.11
2010	Modified exponential	77.53	2.95	-1.36	3.3763	718.83
	Exponential association	47.42	2.50	4.58	3.3792	922.81
	Modified geometric	66.21	3.58	-5.78	3.3854	66.21
2015	Modified exponential	54.74	3.07	-1.47	3.5455	93.72
	Exponential association	44.59	2.60	4.25	3.5496	117.56
	Hyperbolic	51.39	2.76	-2.61	3.5549	100.49

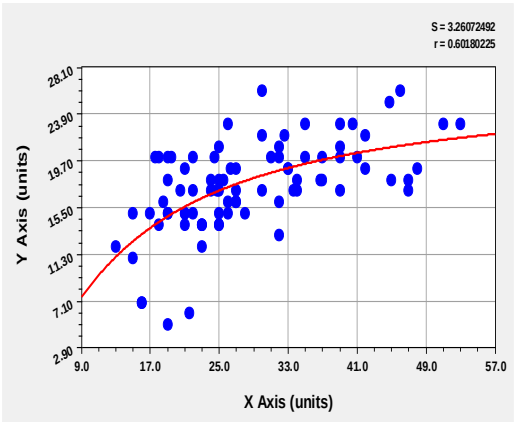


Fig 1

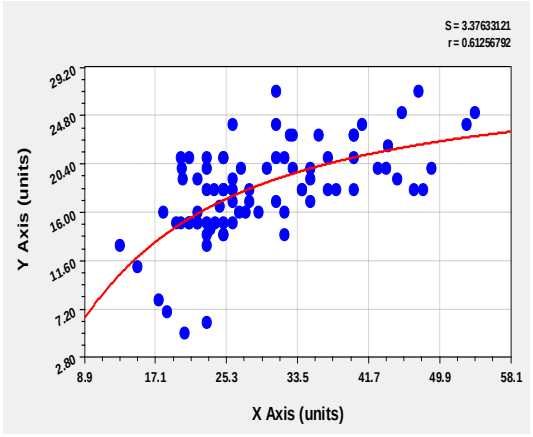


Fig 2

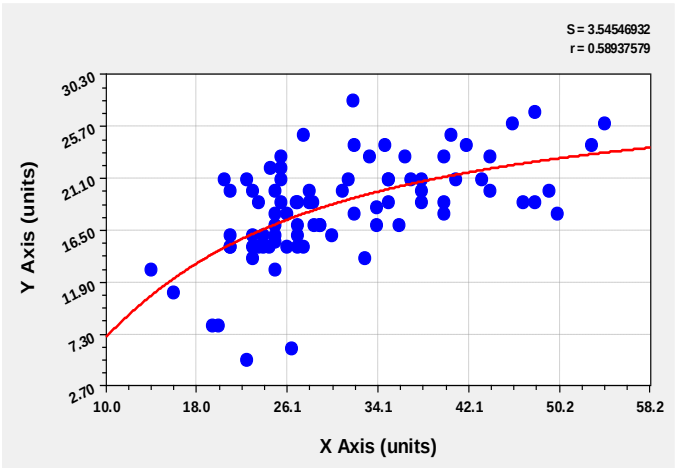


Fig 3

Figures 1, 2 & 3: The modified exponential fit for year 2006, 2010 and 2015, respectively

CONCLUSION

Non-linear growth functions have been commonly used for modelling tree height-diameter relationships. Traditionally the `best ' equation is evaluated and selected based on its statistical properties such as mean squared error, asymptotic *t*-statistics for the parameters, R^2 of the model, AIC and residual analysis (Lianjun, 1997). The result of this study has evidently revealed that nonlinear model can be use to model the tree height-diameter relationship. Meanwhile, modified exponential fit was observed the best fit out of the five models considered. Though, the relationship was weak, this called for more variables such as age, crown area and soil fertility to be incorporated in future prediction of the tree height in the study area. More importantly, the potential tree height-diameter equations should be evaluated and validated for their predictive capabilities (e.g. accuracy, precision, and flexibility) across a range of tree diameters. This useful information can help forest researchers and managers to select and apply the appropriate models.

REFERENCES

Anonymous (2002). Nigeria: Forest Resources. http://www.unep-wcmc.org/forest/data/cdrom2.

Calama, R. and Montero, G. (2004). Interregional nonlinear height–diameter model with random coefficients for stone pine in Spain. *Can. J. For. Res*. 34, 150–163

Curtis, R.O., (1967). Height–diameter and height–diameter–age equations for second growth Douglas-fir. *For. Sci*. 13, 365–375.

Fang, Z. and Bailey, R.L., (2001). Nonlinear mixed effects modeling for slash pine dominant height growth following intensive silvicultural treatments. *For. Sci*. 47, 287–300.

Fang, Z and Bailey, R.L., (1998). Height–diameter models for tropical forests on Hainan Island in southern China. *For. Ecol. Manage*. 110, 315–327.

Fekedulengn, D., Siurtain, M.P.M. and Colbert, J.J. (1999). Parameter estimation of nonlinear growth models in forestry. *Silv. Fenn*. 33, 327–336.

Gregoire, T.G., Schabenberger, O. and Barrett, J.P. (1995). Linear modeling of irregularly spaced, unbalanced, longitudinal data from permanent plot measurements. *Can. J. For. Res*. 25, 136–156.

Huang, S., Titus, S.J., Wiens, D.P., (1992). Comparison of nonlinear height–diameter functions for major Alberta tree species. *Can. J. For. Res*. 22, 1297–1304.

Husch, B., I. M. Charles and W. B. Thomas (2003). *Forest Mensuration*. The Ronald Press Company, New York, U. S. A. pp 120-123.

Ismail, Z. A. Khamis and M. Y. Jaafar, (2003). Fitting nonlinear Gompertz curve to tobacco growth data. *Pak. J. Agro*., 2: 223 – 236

Jaafar, M.Y., (1999). Pensuaian model taklinear Gompertz terhadap pertumbesaran pokok koko. Matematika, 15: 1 – 20

Jayaraman, K. and Zakrzewski, W.T. (2001). Practical approaches to calibrating height–diameter relationships for natural sugar maple stands in Ontario. *For.Ecol. Manage.* 148, 169–177.

Khamis, A. and Z. Ismail, (2004). Comparative study on nonlinear growth curve to tobacco leaf grow data. *J. Agro*., 3: 147 – 153

Lianjun, Z (1997). Cross-validation of Non-linear Growth Functions for Modelling Tree Height-Diameter Relationships. *Annals of Botany* 79: 251-257, 1997

Longman, K. A. and Jenik, K. (2000). *Tropical Forest and its Environment*. Longman 12th Edition, U.K. 147pp.

Lopez Sanchez, C.A., Varela, J.G., Dorado, F.C., Alboreca, A.R., Soalleiro, R.R., Alvarez Gonzalez, J.G. and Rodriguez, F.S., (2003). A height–diameter model for *Pinus radiata* D.Don in Galicia (Northwest Spain). *Ann. For. Sci.* 60, 237–245.

Moore, J.A., Zhang, L., Stuck, D., (1996). Height–diameter equations for ten tree species in the Inland Northwest. *West J. Appl. For.* 11, 132–137.

Navratil, S; Brace, L.G; Sauder, E.A and Lux, S (1994). Silvicultural and harvesting options to favour immature white spruce and Aspen regeneration in Boreal Mixedwoods Can. For. Serv. North. For Cent. Inf. Rep. No. NOR-X-337

Oguntala, A. B. (1981). The Dynamics of Tree Population in Gambari Forest Reserve, Nigeria. *Nig. Jour. of For.* 2:5-9

Peng, C., Zhang, L., Liu, J., (2001). Developing and validating nonlinear height–diameter models for major tree species of Ontario's boreal forests. *North. J. Appl. For.* 18, 87–94.

Peng, C.H., (1999). Nonlinear height–diameter models for nine tree species in Ontario boreal forests, Ont. Min. Nat. Resour., Ont. For. Res. Inst., Sault Ste Marie, ON, *For. Res. Rep* No. 155. 28 pp.

Philip, M.S., 1994. Measuring trees and forests. 2nd Edition CAB International, Wallingford, UK

Pinheiro, J.C. and Bates, D.M., (1998). Model building for nonlinear mixed effects model. Department of Statistics, University of Wisconsin, Madison, WI.

Robinson, A.P. and Wykoff, W.R. (2004). Imputing missing height measures using a mixed-effects modeling strategy. *Can. J. For. Res*. 34, 2492–2500.

SAS, 1992. SAS/STAT: User's Guide, Release 6.03 edition. SAS Institute, Cary, NC.

Sharma, M., Zhang, S.Y., 2004. Height–diameter models using stand characteristics for *Pinus banksiana* and *Picea mariana*. *Scand. J. For. Res.* 19, 442–451.

Temesgen, H. and Gadow, K.V. (2004). Generalized height–diameter models an application for major tree species in complex stands of interior British Columbia. *Eur. J. Forest Res*. 123, 45–51.

Tsoularis, A. and J. Wallace, (2002). Analysis of logistic growth models. Math. *Biosci*., 179: 21 – 55.

Zhang, L., (1997). Cross-validation of non-linear growth functions for modeling tree height–diameter relationships. *Ann. Bot.* 79, 251–257.

Effect of *Gliricidia sepium* Leaves and Cow Dung on the Growth of *Khaya senegalensis* A. Juss. Seedlings

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ABSTRACT

This study was conducted to assess the potential of Gliricidia sepium and cow dung in influencing the growth performance of Khaya senegalensis. The samples of G. sepium and cow dung were mixed with 2 kg of topsoil at different ratios as treatments. There were eleven (11) treatments which include: cow dung (10 g, 20 g, 30 g, 40 g and 50 g) + 2 kg soil, Gliricidia sepium (10 g, 20 g, 30 g, 40 g and 50 g) + 2 kg soil. The treatments were replicated five (5) times and laid out in Completely Randomized Design (CRD). Parameters assessed were plant height, stem diameter, number of leaves and biomass accumulation of component parts of the seedlings. The data collected were subjected to Analysis of Variance (ANOVA) and means were separated using Duncan Multiple Range Test (DMRT) at 5% level of significance. The result showed that there was no significant difference among the treatments at 5% probability level except in plant height. The best performance was recorded in the seedlings raised with T_5 (50 g of cow dung + 2 kg of soil) in plant height, stem diameter and leaves production with a mean value 10.96 cm, 0.32 mm, 7.00 respectively. It is therefore, recommended that cow dung of 50 g should be applied in raising K. senegalensis seedlings.

Keywords: *Khaya senegalensis, Gliricidia sepium,* cow dung, seedlings.

INTRODUCTION

Organic manures are fertilizers from either plants or animals used for improving soil nutrients and consequently to stimulate the growth of plant (Oso, 1995). In Nigeria and other developing countries, the practice of adding organic materials to soils in the nursery has been the common practice in supplementing soil fertility and eventual production of vigorous seedlings (Jackson and Ojo, 1971). *G. sepium* leaves as manure is characterized by fast growth, ability to fix nitrogen, high nitrogen content, tolerance to pruning and to coppicing, good fodder value, high foliage productivity and a vigorous tap root (Kabata, 1983). *Khaya senegalensis* is a large tropical forest trees that belongs to the family Meliaceae, popularly called the Mahogany tree. It is also known for its large tree of 50 m high and 30 m girth (Asiamah, 2000). *Khaya senegalensis* A. Juss is commonly known as Senegal mahogany, it is an evergreen tree that typically grows to a height of 15 – 20 m (up to 35 m on fertile soils) and has a diameter at breast height of 1.5 m, with a clean bole of 8 – 16 m, its natural distribution extends from Mauritania and Senegal East to Northern Uganda with the rainfall range 650 – 1800 mm (Nikiema and Pasternak, 2008).*K. senegalensis* is a multipurpose tree with a variety of economic and environmental value (Nikiema and Pasternak, 2008). It is one of the major timber species in West Africa owing to its hard and fungus and termite resistant red wood, it is highly valued form of carpentry joinery, furniture, ship building and as a decorative veneer. The bark is used in traditional medicine to treat malaria, diarrhoea, dysentery, anaemia etc. Recently, the stem bark has been found to contain chemical (Limonolds) that exhibit antiproliferative activity against human cancer cell lines (Zhang *et al.*, 2007). It is also a good source of fodder for cattle because of its high dry matter but relatively low crude protein content (Ledin *et al.*, 2008). It is also a source of edible and cosmetic (Nikiema and Pasternak, 2008). The wood is usually traded for exterior and interior joinery, veneer and plywood, and it is also used for flooring interior trims, panelling, stairs ship building, vehicle bodies and coffins (Amos *et al.*, 2002).

In West Africa, the species has become an important urban amenity tree, commonly planted as a roadside or ornamental shade tree ; it is also increasingly planted in other countries such as South Africa, Egypt, Australia, Sri-Lanka, China, Indonesia Malaysia and Vietnam for both amenity and timber production (Arnold, 2004). The viability of seed can be prolonged by drying to a moisture content below 5% and storing them at a low temperature of about 50^{o}C (Gamene and Erikson, 2005). The production of healthy vigorous plants require satisfactory growth media, it means that fertility of the growing media is an important factor to consider in the development stage of plants.

Khaya senegalensis grows in forest and is scattered within the higher rainforest savannah wood lands. It is a drought tolerant species but prefers moist site. During the first years, the seedling develop strong deep taproot which makes it the most drought-resistant among the Khaya species. It is also very resistant to flooding and can be considered or planted on swampy soil. Dry zone mahogany remains a dominant species in most of its range (Juss, 2003).

MATERIALS AND METHODS

Experimental Site

The experiment was carried out at the central nursery of Forestry Research Institute of Nigeria, Ibadan. It is located on latitude 7°23`Nand longitude 3°51`E with annual rainfall range between 1,300 – 1,500 mm and relative humidity of 71%. The mean maximum and minimum temperature are 31.9°C and 24.2°C respectively (FRIN, 2013).

Procurement of Materials

The seeds of *K. senegalensis* were collected at Seed Section of Forestry Research Institute of Nigeria, Ibadan (FRIN) while the soil was collected at the *Gmelina arborea* plantation within the premises of Federal College of Forestry, Ibadan. The *Gliricidia sepium* leaves were collected from a mother tree in FRIN while the cow dung was collected from the College's cattle ranch.

Methods

Soil was air-dried and sieved with 2 mm sieve and spread in a germination box. *K. senegalensis* seeds were broadcast into germination box and watered daily for three (3) weeks.
Pre-cropping soil and amendments (cow dung and *G. sepium*) analyses were carried out to determine their nutritional composition. The soil pH was read on the pH meter. Organic matter was determined by the wet oxidation method (Walkley and Black, 1934). Soil P was extracted by the Bray PI extractor and measured by the Murphy blue colouration and determined on a spectronic 20 at 882µm (Murphy and Riley, 1962) Soil Potassium (K), Calcium (Ca) and Magnesium (Mg) were extracted with IM NH40AC,pH7 and were determined with flame photometer, Mg was determined with an atomic absorption spectrophotometer. The total N was determined by the microkjedahl method (AOAC, 1970).
The *Gliricidia sepium* leaves and cow dung were air-dried for 3 weeks and ground into powdery form. Both organic fertilizers were weighed with a bean analytical balance into different ratio and mixed with the soil according to respective treatments. The treatments include:

T_1 - 10 g of cow dung + 2 kg of topsoil
T_2 - 20 g of cow dung + 2 kg of topsoil
T_3 - 30 g of cow dung + 2 kg of topsoil
T_4 - 40 g of cow dung + 2 kg of topsoil
T_5 - 50 g of cow dung + 2 kg of topsoil
T_6 - 10 g of *G. sepium* leaves + 2 kg of topsoil
T_7 - 20 g of *G. sepium* leaves + 2 kg of topsoil
T_8 - 30 g of *G. sepium* leaves + 2 kg of topsoil
T_9 - 40 g of *G. sepium* leaves + 2 kg of topsoil
T_{10} - 50 g of *G. sepium* leaves + 2 kg of topsoil
T_{11} - Control 2 kg of topsoil

The treatments were replicated five (5) times.

Two weeks old seedlings of *K. senegalensis* were pricked into polythene pots filled with the treatments and watered immediately. The following parameters were taken:

a) Plant height (cm) with the aid of a graduated ruler
b) Stem diameter (mm) with the aid of venier calliper and
c) Number of leaves were taken by counting the leaves on each stand

The experiment was monitored for twelve (12) weeks.
After the growth experiment, biomass accumulation was determined by sectioning the seedlings into leaves, stem and root. They were oven-dried at 70°C for twenty-four (24) hours and weighed.

Data Analysis

The experiment was laid out in Completely Randomised Design and the data collected were subjected to Analysis of Variance (ANOVA) and means found to be significant were separated using Duncan Multiple Range Test (DMRT) at 5% level of probability.

Pre-cropping analysis of Soils

Constituents	Quantity
Available P (mg/kg)	2.95
Organic C (g/kg)	9.53
PH (H_2O)	5.54
Total N (g/kg)	1.03
Exchangeable acidity	0.14
Exchangeable bases (C mol/kg)	
Ca (C mol /kg)	2.20
Mg (C mol/kg)	0.21
Na (C mol/kg)	1.67
K (C mol/kg)	0.40
ECEC (C mol/kg)	4.62
Particle size (g/kg)	
Sand	768
Silt	88
Clay	144
Textural class	Sandy loam

Laboratory Analysis of the used *Gliricidia sepium*

Constituents	Quantity
% N	4.166
% P	0.405
% K	1.125
% Ca	0.670
% Mg	0.581
pH	6.500
% Organic Carbon	29.735
% Organic Matter	51.790

S**ource**: Laboratory analysis, 2015

Laboratory Analysis of the used cow dung

Constituents	Quantity
C	18.23 Cmol/kg
N	1.34 Cmol/kg
P	1.5 Cmol/kg
K	0.6701 Cmol/kg
Na	1.34 Cmol/kg
Ca	2.34 Cmol/kg
Mg	0.21 Cmol/kg
Cu	20.4 mg/kg
Zn	120.6 mg/kg
Fe	340 mg/kg
Mn	115 mg/kg

Source: Laboratory analysis, 2015

RESULTS AND DISCUSSION

Plant Height of *K. senegalensis* seedlings as influenced by cow dung and *G. sepium*

Analysis of Variance (ANOVA) indicated that there were significant differences ($p \leq 0.05$) in height of *K. senegalensis* seedlings grown with different quantities of fertilizers (Table 1). However, the highest plant height was observed when T_5 (10.96 cm) was used

as an amendment while the least plant height was observed when the soil was not amended (control) with 8.81 cm (Figure 1). Plants height was markedly influenced by all plots receiving treatments. This is accordance with the research of Anderson (2008) who used poultry droppings and NPK on the growth of *K. senegalensis* and observed that poultry droppings an example of organic manure, performed best on *K. senegalensis*. This however, indicates that organic manure from animal source may perform better than those from plant source, although the result may not be significantly different from one another.

Table 1: ANOVA for the Effect of Fertilizers on the Growth of *K. senegalensis* seedlings

Variable	SV	Df	SS	MS	F	Sig.
Height	Treatment	10	19.58	1.96	4.15	0.00*
	Error	44	20.77	0.47		
	Total	54	40.35			
Stem Girth	Treatment	10	0.01	0.00	0.79	0.64^{ns}
	Error	44	0.06	0.00		
	Total	54	0.07			
Leaves Production	Treatment	10	1.92	0.19	0.31	0.97^{ns}
	Error	44	27.17	0.62		
	Total	54	29.08			

***significant at (p≤0.05)* ns- not significant (p>0.05**

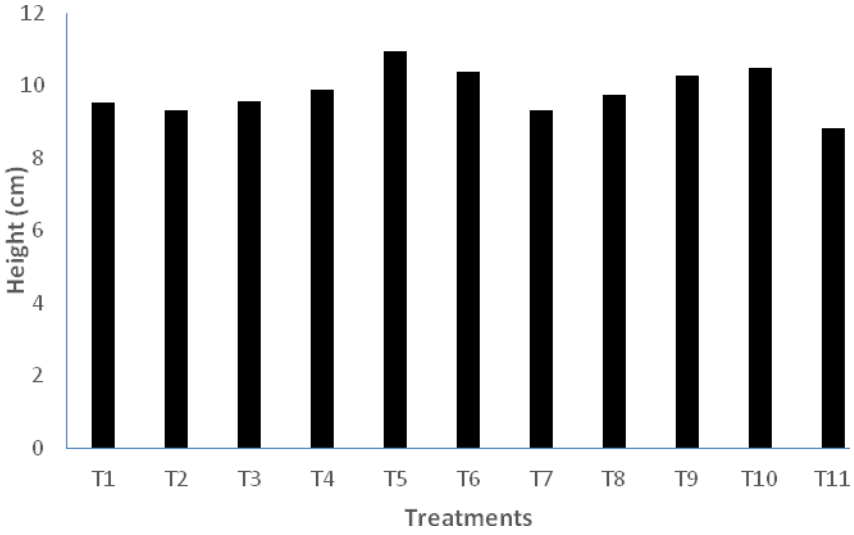


Figure 1: Mean Height of *K. senegalensis* Seedlings

Stem diameter of *K. senegalensis* seedlings as influenced by cow dung and *G. sepium*

There was no variation observed (p>0.05) in stem diameter of *K. senegalensis* seedlings among all treatments used (Table 1). However, the mean value shows that the seedlings grown with T_5 gave the highest value of stem diameter (0.32 mm) while seedlings grown with T_7 gave the least growth in terms of collar diameter (0.26 mm) (Figure 2). Both cow dung and *G. sepium* manures have positive effect on the stem diameter of *K. senegalensis* seedlings and this is in accordance with the finding of Munson *et al.,*(1985) and cited by El Siraf *et al.,(*2008).that stem diameter of *Eucalyptus saligna* with the use of organic manure was significantly higher. *Shokeye (2007) also* who worked on the effect of horse dung, NPK, *Leucaena leucocephela* on the growth *of Khaya grandifoliola* and discovered that mixture of horse dung and *Leucaena leucocephela* performed best on the stem diameter of the seedlings.

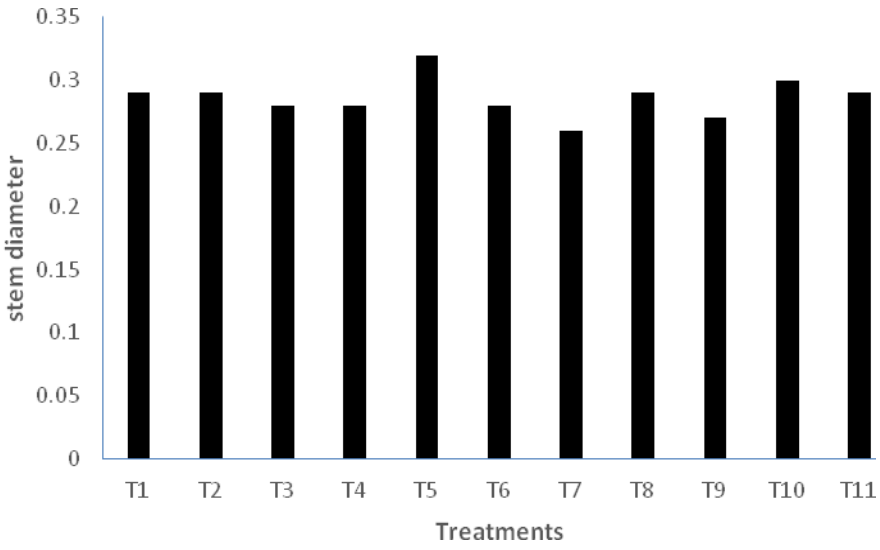


Figure 2: Mean Stem diameter of *K. senegalensis*

Leaves Production of *K. senegalensis* seedlings as influenced by cow dung and *G. sepium*

There was no significant difference ($p>0.05$) in the leaves production of *K. sengalensis* seedlings among all treatments used (Table 1). However, the mean values shows that the seedlings grown with T_1, T_2, T_3, T_5, T_6, T_7, and T_8 has the highest number of leaves while seedlings grown with T_4, T_9, T_{10} and T_{11} has the least among the treatments (Figure 3)

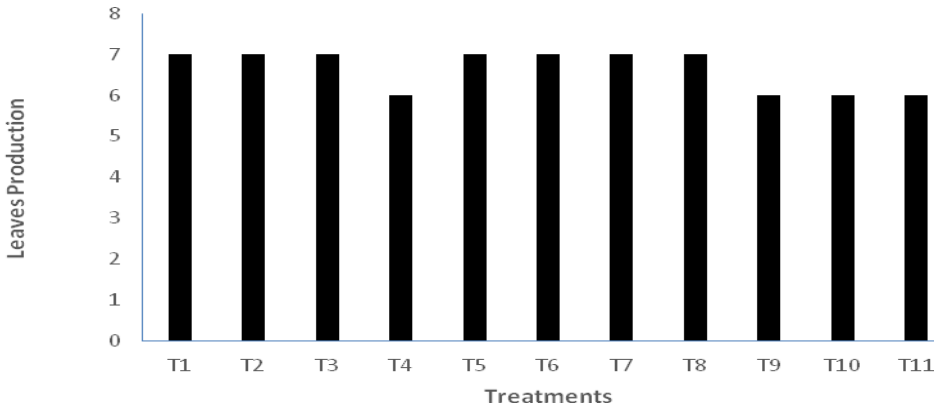


Figure 3: Mean Leaves Production for *K. senegalensis* Seedlings

Leaf Dry Weight (LDW) of *K. senegalensis* seedlings as influenced by cow dung and *G. sepium*

There was no significant difference ($p>0.05$) in the LDW of *K. senegalensis* seedlings among all treatments used (Table 2). However, seedlings grown with T_3, T_4, T_5 and T_{11} gave the highest mean value of LDW (2.67 g) while seedlings grown with T_1 gave the least growth in mean LDW (1 g) (Figure 4).

Table 2: ANOVA for the effects of cow dung and *G. sepium* on the biomass accumulation of *K. senegalensis* Seedlings

Variable	SV	Df	SS	MS	F	Sig.
Leaf Dry Weight	Treatment	10	1.335	0.134	0.355	0.953^{ns}
	Error	22	8.267	0.376		
	Total	32	9.602			
Stem Dry Weight	Treatment	10	2.303	0.23	0.345	0.957^{ns}
	Error	22	14.667	0.667		
	Total	32	16.97			
Root Dry Weight	Treatment	10	1.394	0.139	0.46	0.898^{ns}
	Error	22	6.667	0.303		
	Total	32	8.061			

ns- not significant (p>0.05)

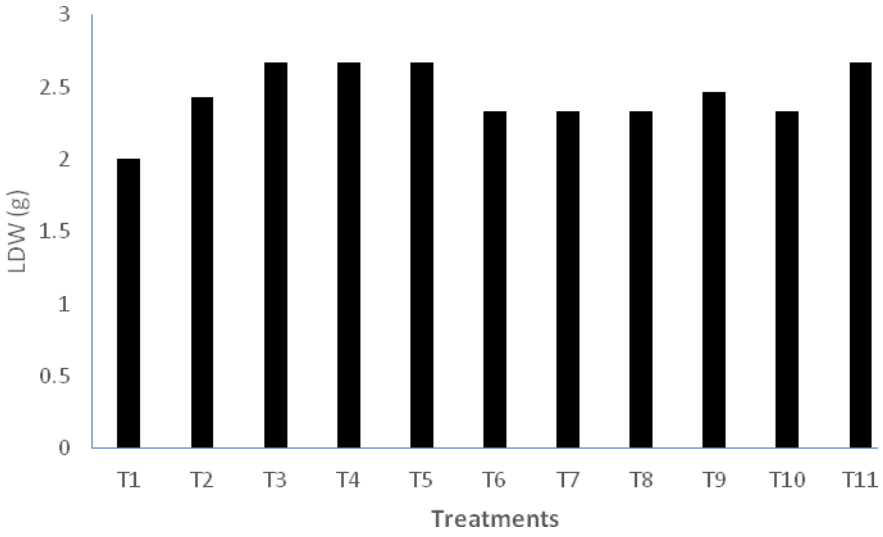


Figure 4: Mean LDW of *K. senegalensis* Seedlings

Stem Dry Weight (SDW) of *K. senegalensis* seedlings as influenced by cow dung and *G. sepium*

There was no significant difference (p>0.05) in the SDW of *K. senegalensis* seedlings among all treatments used (Table 2). However, seedlings grown with T_5 gave the highest mean value of SDW (2.33 g) while seedlings grown with T_7 and T_9 gave the least growth in mean SDW (1.33 g) (Figure 5).

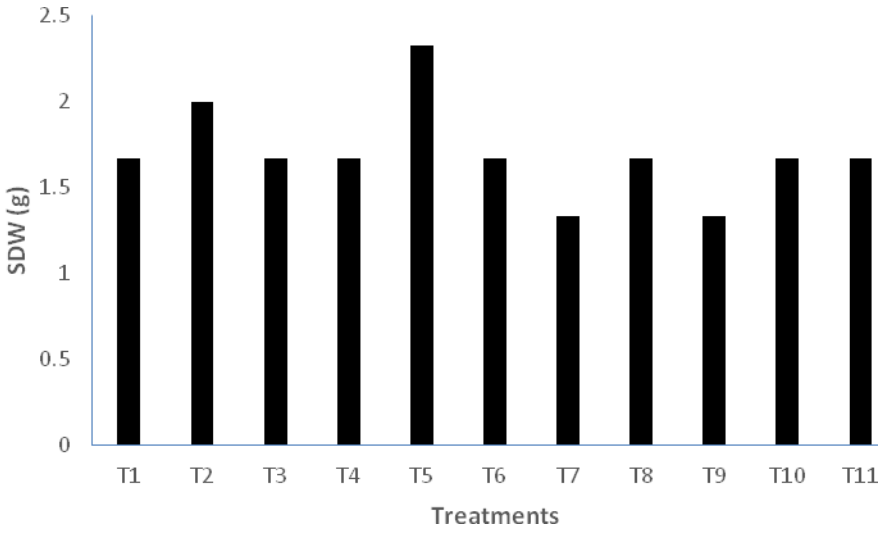


Figure 5: Mean SDW of *K. senegalensis* Seedlings

Root Dry Weight (RDW) of *K. senegalensis* seedlings as influenced by cow dung and *G. sepium*

There was no significant difference ($p>0.05$) in the RDW of *K. senegalensis* seedlings among all treatments used (Table 2). However, seedlings grown with T_2, T_5, T_7 and T_9 gave the highest mean value of SDW (1.67 g) while seedlings grown with T_{11} gave the least growth in mean SDW (1 g) (Fig. 6).

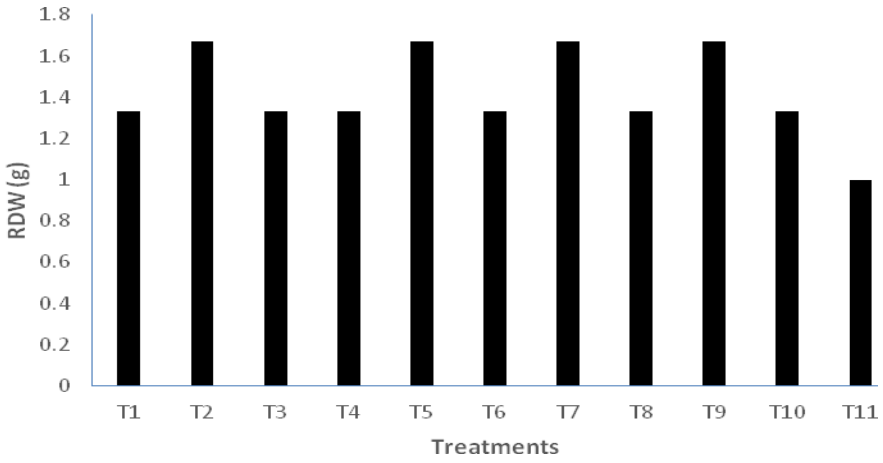


Figure 6: Mean RDW of *K. senegalensis* Seedlings

CONCLUSION AND RECOMMENDATION

From the results obtained, T_5 with 50 g of cow dung performed best on *Khaya senegalensis /* seedlings in plant height stem diameter, and leaf production, than any other treatments because of its organic materials which are chemically, physically and biologically improved. The differences in the treatments were not significant at 5% level in stem diameter and leaf production except in the plant height. Therefore, the experiment revealed that cow dung can influence the growth and development of *K. senegalensis* seedlings. The study also showed the potentials of cow dung over *G. sepium* leaves for improved growth of *K. senegalensis* seedlings. It can be concluded that addition of cow dung as manure to *K. senegalensis* seedlings will better produce healthy and vigorous seedlings in a short period of time rather than using *G. sepium* leaves.

REFERENCES

Arnold, R. (2004): "*Khaya senegalensis* current use from its natural range and its potential in Sri lanka and elsewhere in Asia in prospects of High-Value hardwood timber plantation in the 'Dry' Tropies of Northern Australia, Mereeba Australia..

AOAC, (1970): Official Method of Analysis *12th Edition Association of Official Analytical Chemist, Washington, D.C, USA.*

Asiamah, I. (2000): Chemical constituents of the seed of *Entandrophragma angolense*. B. Sc. thesis submitted to the Department of Chemistry, Faculty of Science, University of Cape Coast Ghana 36pp.

Gamene, C. S. and Erikson, E. N. (2005): "Storage Biology of Tropical Tree Seeds M. Scande, D. Joker, M.E. Dullo and K.A., Thomsen, Eds; Pp 9 – 15, International Plant Genetic Resources Institute (IPGRI), Rome, Italy

Jackson, J. K and Ojo, O. (1971): Productivity of natural woodland and Plantation in the Savannah zone of Nigeria. *Nigeria Journal of Forestry* 1 (2) 57 – 60 Pp.

Juss, A. (2008): *Khaya senegalensis* desr, Agroforestry Tree Center Vol.66.www.unesdoc.unesco.org.

Kabana P. (1983): Climate soil and vegetation; University of Tutorial Press Limited Pp 181 – 182.

Murphy J. and Riley, J. P., (1962): A modified single solution method for determination of phosphate in natural waters. *Analytics Glumi-Acta 27:31-36.*

Nikiema, A and Pasternak, D. (2008): "K. Senegalensis (Desr.) A. Juss" in plant Resource of Tropical Africa D. Louppe, A., Oteng. Amoako and M. Brink, Eds., Pp 339 – 344, PROTA foundation Wageningen, the Netherlands.

Olusola O. A, Olukemi Y. A, Henry A. A and Adekemi O. S., (2014) Int. J. Biol. Chem. Sci. 8(5): 2071-2080.

Oso B. R. (1995): Potentials of hyacuth azola and other weed as organic fertilizer, University of Ibadan 78 Pp

Walkley, A. and Black, I. A., (1934): An examination of Degtajaroff method for determining soil organic acid filtration method. *Soil Science 37: 29-38.*

Zhang, H.P., Wang, F., Chen, X., Androulakis, A and Wargovich, M.J. (2007): "Anticancer activity of limonaid from *K. senegalensis*" Phytotherapy Research, Vol. 21, No 8, Pp 731 – 734.

Assessment of Phenotypic Plasticity of *Azadirachta indica* (A. JUSS) in Three Ecological Zones of Nigeria

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ABSTRACT

This study assessed diverse folia morphologies exhibited by Azadirachta indica towards adapting to various climatic conditions in different ecological zones of Nigeria. The research work was carried out in three ecological zones of Nigeria namely: Rainforest (Akure), Derived Savanna (Ekiti) and Guinea Savanna (Ilorin). In each ecological zone, ten trees at not less than 50 meters apart were randomly selected and ten leaves were collected from each of the selected trees. The number of leaflets on each leave were counted and recorded. Subsequently, two leaves were randomly selected from the ten leaves and all the leaflets were measured using Leaf Area Meter. Variables measured include: Leaflet Surface Area (LSA), Leaflet Length (LL), Leaflet Width (LW), Apex Length (AL) and Degree of Obliqueness (DO). Geographical Position System (GPS) location of each tree was also recorded. Findings from this research indicated that all the folia morphological variables reduced as one moved from rainforest to derived savanna and guinea savanna ecological zones respectively. However, folia characteristics of Azadirachta indica trees in the same ecological zone were not significantly different.

Keywords: Phenotypic plasticity, ecological zone, morphology, folia characteristic

INTRODUCTION

Azadirachta indica is a small to medium-sized tree, usually evergreen (Orwa *et. al.*, 2009), it belongs to Kingdom: Plantae, Order: Rutales, Suborder: Rutinae, Family: Meliaceae, Subfamily: Melioideae, Tribe: Melieae, Genus: *Azadirachta*, Species: *indica* (Hashmat *et. al.*, 2012). Hashmat *et. al.*, (2012) reported that *Azadirachta indica* commonly known as neem, is native of India and naturalized in most of tropical and subtropical countries. In India, it grows in regions with absolute minimum and maximum temperatures of 0 and 49°C, respectively. Neem can tolerate high summer temperatures (up to 50˚C) but does not tolerate frost or temperatures below 4˚C (leaf fall and death may result). Neem grows best in areas where annual rainfall is 450–1200 mm (with optimum growth where annual rainfall is around 1100 mm), but can tolerate annual rainfall as low as 150 mm if its roots can access ground water within 9 – 12 m of the ground surface (Stoney, 1997 cited in Csurhes., 2008). Once established, it is very drought tolerant and can survive 7 – 8 month dry seasons (Csurhes, 2008). According to Nicotra *et al* (2010), Climate change is altering the availability of resources and the conditions that are crucial to plant performance. One way plants will respond to these changes is through environmentally induced shifts in phenotype (phenotypic plasticity). According to Kelly *et al.*, (2012) phenotypic plasticity can be broadly defined as the ability of a genotype to produce different phenotypes in response to different environmental conditions.

According to Auld *et. al., (*2009), in nature where environmental conditions continually vary, individual is confronted with the challenge of taking full advantage of fitness under diverse conditions. Species inhabit a large geographical array or a variety of different habitat within a limited area, or both, phenotypic plasticity has been broadly recognized as a significant feature for plants to cope with varying environmental heterogeneity (Abrams, 1994; Lamarque *et al*, 2013; Valladares *et. al.*, 2007). Coleman *et. al.*, (1994) also buttress that environmentally-induced phenotypic variation (phenotypic plasticity) in plants is often considered to be a functional response that maximizes fitness in variable environments. These plastic responses include changes in behavior, physiology, morphology, growth, life history and demography, and can be expressed either within the lifespan of a single individual or across generations (Miner *et al*, 2005). When populations experience suboptimal conditions, the mechanisms involved in the regulation of phenotypic variation can be challenged, resulting in increased phenotypic variance. This kind of disturbance can be diagnosed by using morphometric tools to study morphological patterns at different hierarchical levels (Lazic *et al*, 2015).

Azadirachta indica is one of the most versatile medicinal plants; almost all of its parts (leaves, bark, flower, fruit, and root) have long been used in Iranian, Indian, and Chinese traditional medicine (Sharafkandi, 1991; Biswas et al., 2002; Khare, 2007 cited in Jafari *et.*

al., 2012). In South West Nigeria, the upsurge in ethno-botanical studies and scientific research into the use of plant species has further enhanced the pressure on populations of medicinal forest species as more people now use plants' parts for treating various body ailments, which makes the species to be part of the threatened species reported by IUCN list (FAO, 2003 cited in Monica., 2005). However, the consequential destruction of the natural habitats also resulted in the loss of biodiversity. Hence, this research work assessed the morphological adaptability that exists in *Azadirachta indica* in three ecological zones of Nigeria. According to Nicotra *et. al.*, (*2010)* responses to environmental changes in any given plant species will require an understanding of the environmentally induced variation in the phenotype of individual tree. This induced variation when known could be used in breeding program to develop other species adaptable to varying environmental condition. Hence, the need to assess phenotypic plasticity of *Azadirachta indica* in three ecological zones of Nigeria.

MATERIALS AND METHODS

Study Area

The research was carried out in Akure, Ondo State (Rainforest), Otun Ekiti, Ekiti State (Derived Savanna) and Ilorin, Kwara State (Guinea Savanna).

Sample Collection

Samples were collected in Akure, Ekiti and Ilorin (Figures 1, 2 and 3). In each ecological zone, ten trees at not less than 50 meters apart were randomly selected and ten leaves were collected from each of the selected trees. Each tree assessed in different ecological zones were more than 50 meters apart this is because closely related species show more similar patterns of plasticity than distantly related species, regardless of non-native or invasive status (Cook-Patton and Agrawal, 2011). The number of leaflets on each leave were counted and recorded. Subsequently, two leaves were selected randomly from the ten leaves and all the leaflets in the two leaves were measured using Leaf Area Meter. Variables measured include: leaflet surface area (LSA), leaflet length (LL), leaflet width (LW), apex length (AL) and degree of obliqueness (DO). Geographical Position System (GPS) location of each tree was also recorded.

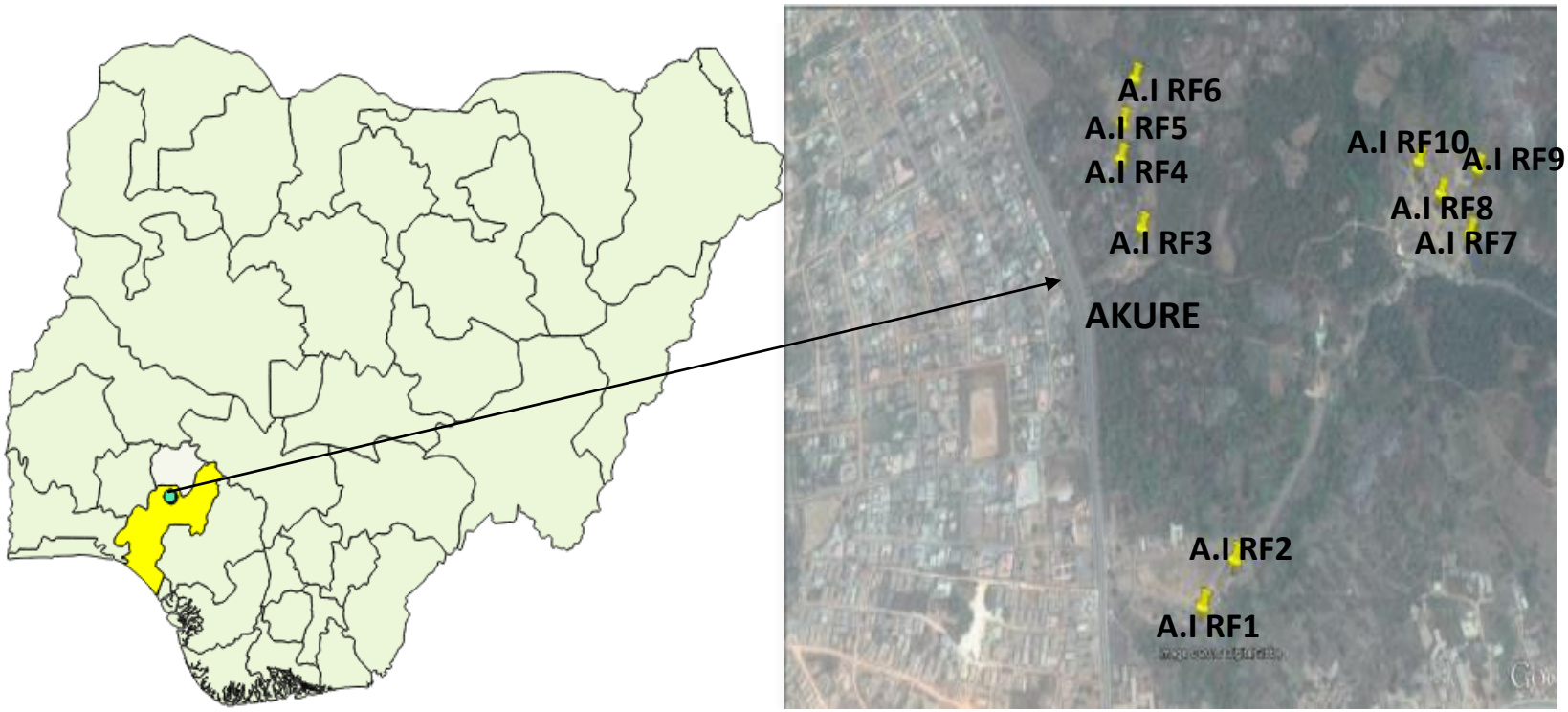


Plate 1: Map of Nigeria Showing Where Samples were Collected in Ondo State
NOTE: A.I - *Azadirachta indica*, **RF -** Rainforest, **DS –** Derived Savanna and **GS –** Guinea Savanna

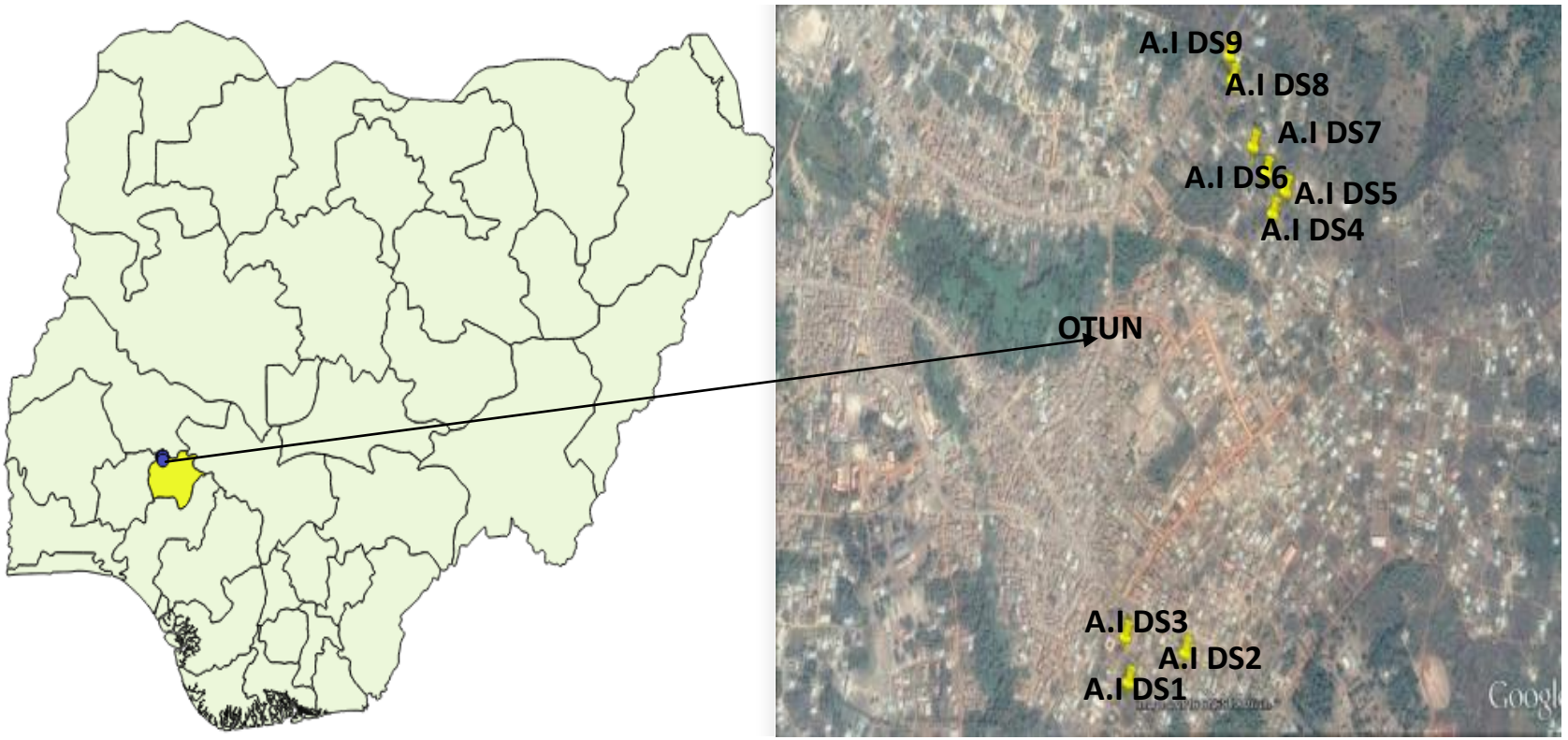


Plate 2: Map of Nigeria Showing Where Samples were Collected in Ekiti State
NOTE: A.I - *Azadirachta indica*, **RF -** Rainforest, **DS –** Derived Savanna and **GS –** Guinea Savanna

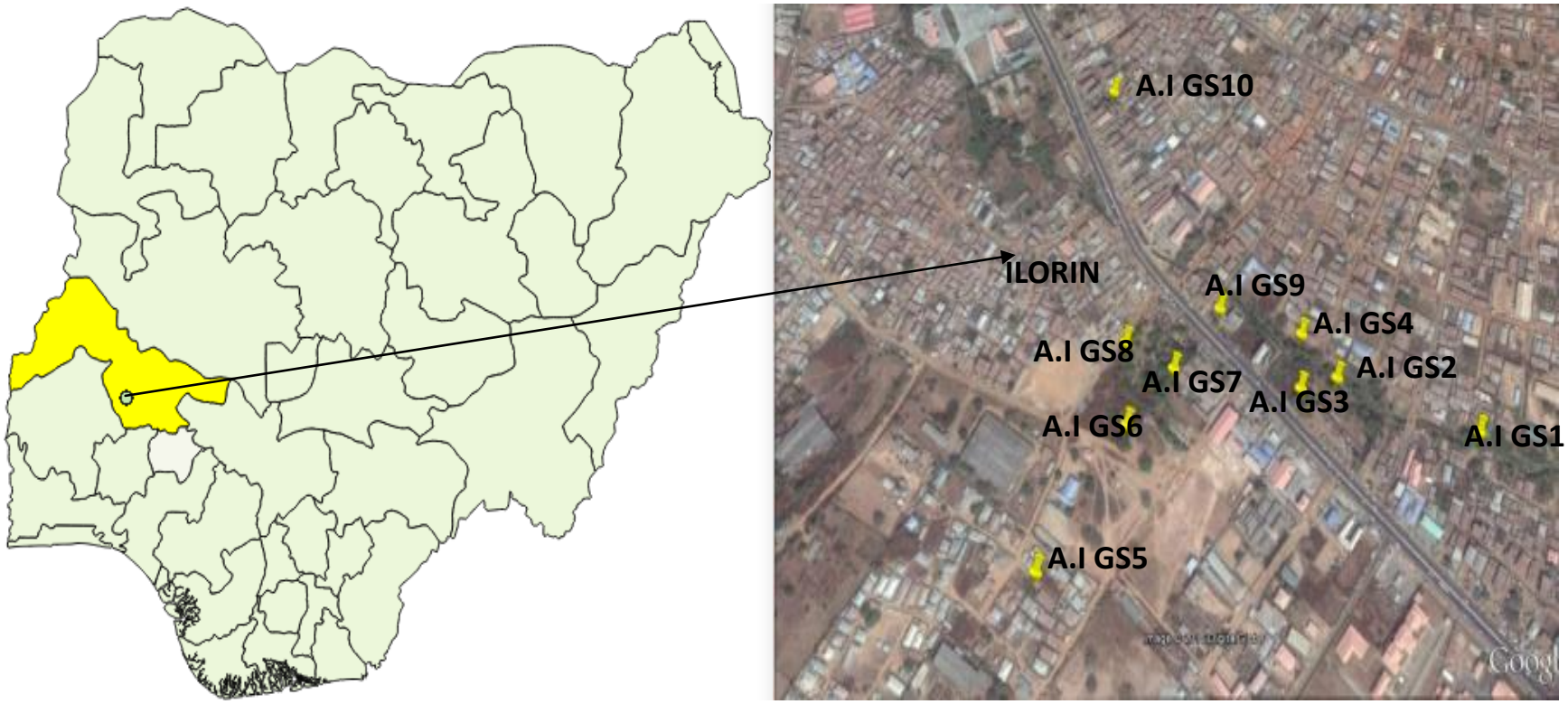


Plate 3: Map of Nigeria Showing Where Samples were Collected in Kwara State

NOTE: A.I - *Azadirachta indica*, **RF -** Rainforest, **DS –** Derived Savanna and **GS –** Guinea Savanna

DATA ANALYSIS

The Data obtained was analyzed using Statistical Package for Social Sciences (SPSS) version 21 to test for significance differences among the variables measured across the ecological zones. Intra-and inter morphology relationship in *Azadirachta indica* was determined using sequential agglomerative hierarchical cluster analysis. Obtained result was used to construct a final dendrogram.

RESULTS

Comparism of Leaflet Surface Area among the Ecological Zones

The Analysis of Variance (ANOVA) for leaflet surface area of leaflets collected from three ecological zones is presented in Table 1. The results revealed that there was significant difference between leaflet surface area among the three ecological zones. Hence, the need for the follow up analysis and the result is presented in Table 2. The leaflet surface area was found to be significantly higher in Rainforest trees (10.6694m^2), followed by Derived Savannah (9.5637m^2) and Guinea Savanna (7.6034m^2), respectively.

Table 1: Analysis of Variance for Comparing Leaflet Surface Area among Three Ecological Zones

Source of Variation	Sum of Squares	Decree of Freedom	Mean Square	F	Significance
Leaflet Surface Area	1375.169	2	687.584	59.519	0.000*
Error	9900.414	857	11.552		
Total	11275.582	859			

**=significant while ns= not significant (P>0.05)*

Table 2: Duncan Multiple Range Test for Leaflet Surface Area

Ecological Zones	Mean ± SE
Guinea Savanna	7.6034±0.15128[c]
Derived Savanna	9.5637±0.17250[b]
Rainforest	10.6694±0.25048[a]

Comparism of Leaflet Length among the Ecological Zones

The Analysis of Variance (ANOVA) for leaflet length of leaflets collected from three ecological zones is presented in Table 3. The result revealed that there is significance difference between leaflet length among the three ecological zones. According to the Table 4, the leaflet length was found to be significantly higher in Rainforest trees (7.5555cm), followed by Derived Savannah (6.7171cm) and Guinea Savanna (6.2654cm) respectively.

Table 3: Analysis of Variance for Comparing Leaflet Length Area among Three Ecological Zones

Source of Variation	Sum of Squares	Decree of Freedom	Mean Square	F	Significance
Leaflet length	249.804	2	124.902	42.527	0.000*
Error	2516.991	857	2.937		
Total	2766.795	859			

**=significant while ns= not significant (P>0.05)*

Table 4: Duncan Multiple Range Test for Leaflet Length

Ecological Zones	Mean ± SE
Guinea Savanna	6.2654±0.09180[c]
Derived Savanna	6.7171±0.09814[b]
Rainforest	7.5555±0.11017[a]

Comparism of Leaflet Width among the Ecological Zones

The Analysis of Variance (ANOVA) for leaflet width of leaflets collected from three ecological zones is presented in Table 5. The result revealed that there is significance difference between leaflet width among the three ecological zones. According to the Table 6, the leaflet width was found to be significantly higher in Rainforest trees (2.9410cm), followed by Derived Savannah (2.7652cm) and Guinea Savanna (2.4783cm), respectively.

Table 5: Analysis of Variance for Comparing Leaflet Width among Three Ecological Zones

Source of Variation	Sum of Squares	Decree of Freedom	Mean Square	F	Significance
Leaflet Width	31.165	2	15.582	26.281	0.000*
Error	508.137	857	0.5930		
Total	539.301	859			

**=significant while ns= not significant (P>0.05)*

Table 6: Duncan Multiple Range Test for Leaflet Width

Ecological Zones	Mean ± SE
Guinea Savanna	2.4783 ± 0.04648^{c}
Derived Savanna	2.7652 ± 0.04159^{b}
Rainforest	2.9410 ± 0.04648^{a}

Comparism of Leaflet Apex Length among the Ecological Zones

The Analysis of Variance (ANOVA) for apex length of leaflets collected from three ecological zones is presented in Table 7. The result revealed that there is significance difference between apex length among the three ecological zones. The result of the follow-up test as presented Table 8 revealed that the leaflet apex was found to be significantly higher in Rainforest trees (1.1716cm), followed by Derived Savannah (1.0656cm) and Guinea Savanna (0.9651cm), respectively.

Table 7: Analysis of Variance for Comparing Apex Length among Three Ecological Zones

Source of Variation	Sum of Squares	Decree of Freedom	Mean Square	F	Sig.
Apex Length	6.155	2	3.077	64.173	0.000*
Error	41.097	857	.048		
Total	47.252	859			

**=significant while ns= not significant (P>0.05)*

Table 8: Duncan Multiple Range Analysis for Apex Length

Ecological Zones	Mean ± SE
Guinea Savanna	0.9651 ± 0.01283^{c}
Derived Savanna	1.0656 ± 0.01293^{b}
Rainforest	1.1716 ± 0.01412^{a}

Comparism of Leaflet Degree of Obliqueness among the Ecological Zones

The Analysis of Variance (ANOVA) for degree of obliqueness of leaflets collected from three ecological zones is presented in Table 9. The result revealed that there is significance difference between degree of obliqueness among the three ecological zones. The follow-up result indicated that the degree of obliqueness was found to be significantly higher in Rainforest trees (0.5605cm), followed by Derived Savannah (0.5216cm) and Guinea Savanna (0.5185cm) respectively as presented in Table 10.

Table 9: Analysis of Variance for Comparing Degree of Obliqueness among Three Ecological Zones

Source of Variation	Sum of Squares	Decree of Freedom	Mean Square	F	Sig.
Degree of Obliqueness	0.323	2	0.162	3.788	0.023*
Error	36.582	857	0.043		
Total	36.905	859			

**=significant while ns= not significant (P>0.05)*

Table 10: Duncan Multiple Range Test Follow Up Analysis for Degree of Obliqueness

Ecological Zones	Mean of Degree of Obliqueness
Guinea Savanna	0.5185 ± 0.01128^{c}
Derived Savanna	0.5216 ± 0.01042^{b}
Rainforest	0.5605 ± 0.01412^{a}

Phenetics Analysis of Sampled Neem Trees

Figure 4 is the dendogram showing the relationship among sampled trees of *Azadirachta indica* in the study area. As much as trees from the same ecological zone formed a grouped (TDS7, TDS10, and TDS8), trees from the different ecological zones were also found together as a group (TRF4, TDS2 and TGS10). Also, trees from Rainforest and Derived Savanna formed a clade as well (TRF2 and TDS5).

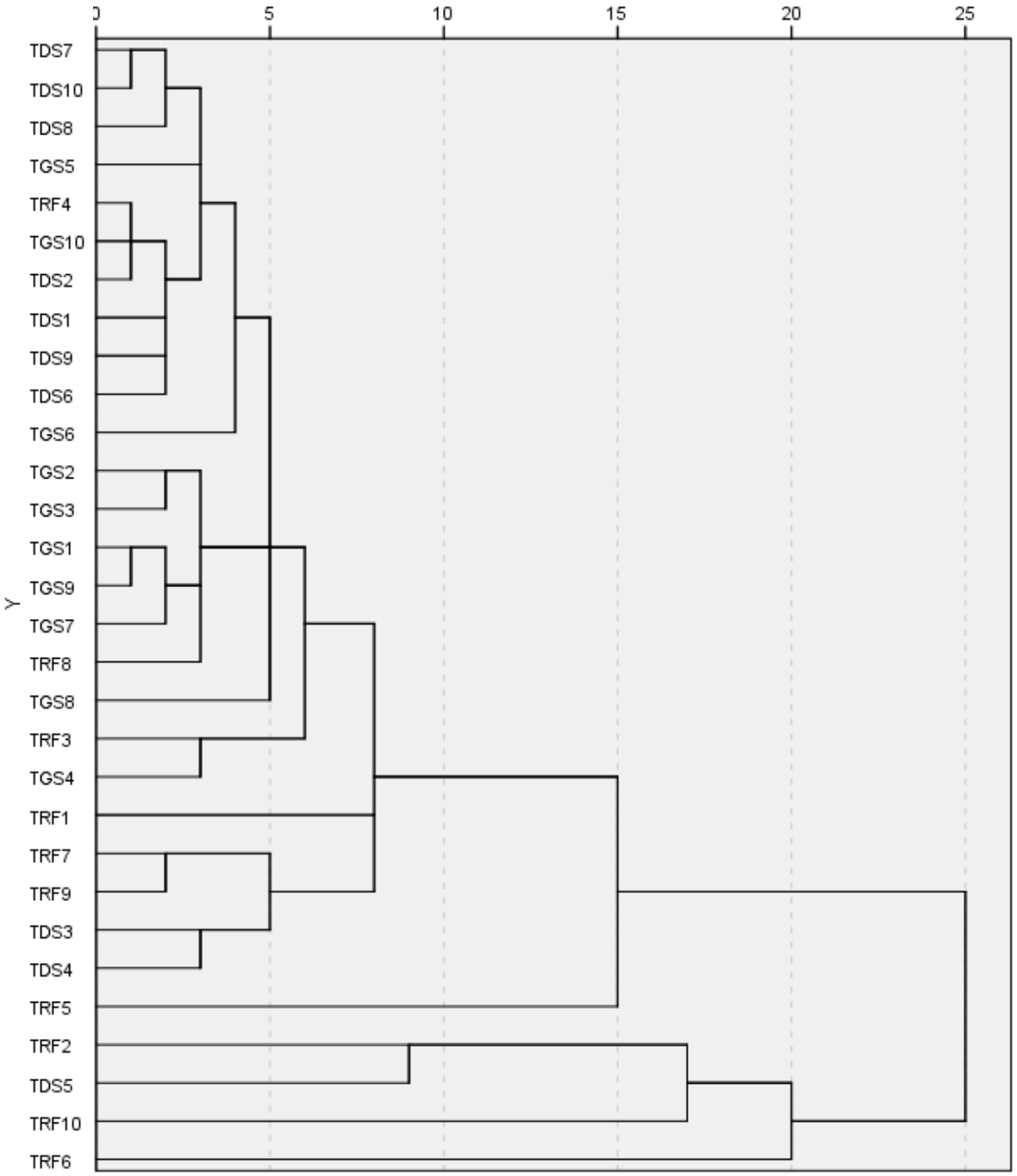


Figure 1: Dendogram showing accessions of sampled *Azadirachta indica* trees from three Ecological Zones of Nigeria.

NOTE: TRF - Tree Rainforest, **TGS** - Tree Guinea Savanna**, TDS** - Tree Derived Savanna

DISCUSSION

Leaflet surface area was found to vary among the three ecological zones. This is expected as the variations in leaf size along climatic gradients may result from greater evaporative demand of larger leaves due to enhanced thickness of the boundary layer for energy and gaseous exchange (Royer *et. al.,* 2005 cited in Xu *et. al.,* 2009). Implication of this result was discussed by Xu *et. al.,* (2009) that leaf surface area is an important parameter which dictates growth rate, the larger the specific leaf area, the larger the area for capturing light per unit of previously captured mass. It implies that neem tree in rainforest forest will be doing well in their overall wellbeing because they can capture more light to generate food (sugar) while neem tree in the guinea savanna will capture less light which can lead to producing less food; their overall wellbeing will definitely be less when compared to neem trees in the rainforest. The result supported (Gordon, 2005) statement that leaves growing in sunny environments are smaller than leaves growing in shaded environments. Xu *et. al.,* (2009) buttressed that their study highlighted that leaflet size was obviously restricted with a short supply of water.

Decrease in the surface area of a leaflet relative to its perimeter length, allowing for greater heat and moisture transfer. Small leaves provide a thin boundary layer and result in efficient heat transfer. Another study found that large leaves are expected in the humid, shaded environment of the forest understory while small leaves occur in the sunny, dry conditions of the forest overstory (Gordon, 2005). This concur with the Akure climatic condition that the rainfall is about 1524mm per year, the atmospheric temperature ranges between 28^0C and 31^0C with mean annual relative humidity of about 80 per cent and that of Ilorin which experiences annual mean rainfall of about 1,150mm, hot days during the dry season, temperature typically ranges from 33 - 34°C while between February to April, values are frequently between 34.6 and 37°C. This result validates Niinemets *et. al.,* (2007) findings that leaf sizes decline due to overall resources limitation in stressful environments.

The follow up analysis of variance test carried out on leaflet length and leaflet width showed that neem tree from Rainforest ecological zone has the highest mean length and width of 7.5555±0.11017cm and 2.9410±0.04648cm respectively followed by leaflets from Derived Savanna with length and width of 6.7171±0.09814cm and 2.4783±0.04648cm respectively. Leaflet length in Derived Savanna was closely followed by Guinea Savanna (6.2654±0.09180 and 2.7652±0.04159) Leaflet length and width respectively. This result showed that leaflet length and leaflet width increased along with the expansion of leaflet surface area (Xu *et. al.,* 2009). This is against the statement of Niinemets *et. al.,* (2007) that leaf elongation characterizes the overall slenderness of the leaves. It reflects the integrated changes of leaf major and minor axes. Leaflets from Rainforest ecological zone has the highest mean of leaflet length but maintains the highest mean leaflet surface area while that of Guinea Savanna are smaller in length and has the lowest mean leaflet surface area.

Follow up analysis test result showed that leaflets from the Rainforest ecological zone has longer apex and it is more oblique with mean value of 1.1716±0.01412cm and 0.5605±0.01412cm respectively. Leaflets from Guinea Savanna has shorter apex length and less oblique with the value of 0.9651±0.01283cm and 0.5185±0.01128cm respectively. Degree of obliqueness was obtained from the distance of each half of the leaflet from the petiole. These findings were supported by Lovett and Haq (2000); Wright and Westoby (1999); Yates *et. al.,* (2010) that a narrow leaf with smaller petiole size is viewed as an adaptation to sunny and dry environments for controlling water balance. This result corresponds with the findings of Niinemets *et. al.,* (2006). They opined that changes of petiole length were consistent with changes of leaflet area and dry mass, which indicated that there was a positive relationship between leaf petiole length and leaf size. Due to the economics of light interception and biomechanical requirements, increases in leaf size are often bound to enhanced biomass investment in the petiole. The implication is that the elongation of petioles will achieve optimal leaf display to deal with the denseness of the canopy, but it may not be the major way to reduce self-shading, as the plants face a trade-off between the need for increasing interception areas and support structures. Increasing the investment in petioles needs to synthesize more xylogens, and longer petioles will lead the leaf to bend (Pickup *et. al.,* 2005). The similarities observed among trees from the three ecological zones as revealed in the dendogram can be attributed to the age of the tree. Other source of similarities can be the site quality or environmental condition of where the tree is located.

CONCLUSION AND RECOMMENDATION

This research work affirmed that leaf sizes are restricted by environmental conditions. The leaf can be considered as a microcopy of the plant, and the variations of leaf morphology can reflect the plant capacity to acquire, use and conserve resources. The study of leaf trait differences may contribute to our understanding of optimum habitat conditions and the ecophysiological adaptations of plants. More so, folia characteristics of *Azadirachta indica* in the same ecological zone were found to be significantly the same in this study.

Immediate attention should be given to the rapid change in climate by concerned groups, organizations, firms and government agencies.

REFERENCES

Adekunle V.A.J. (2006): Conservation of tree species diversity in tropical Rainforest ecosystem of south-west Nigeria. *Journal of Tropical Forest Science* 18(2), 91-101

Auld J.R., Agrawal A.A. and Relyea R.A. (2009): Re-evaluating the costs and limits of adaptive phenotypic plasticity. *Proceedings of the Royal Society (Biological Sciences),* 277, 503-511

Csurhes S. (2008). *Pest plant risk assessment: Neem tree Azadirachta indica*. Biosecurity Queensland Department of Primary Industries and Fisheries, Queensland, Brisbane. 16pp

Forsman A. (2015): Heredity. Rethinking phenotypic plasticity and its consequences for individuals, populations and species, 115, 276-284

Gordon, B. (2015): ECOLOGICAL CLIMATOLOGY. *Leaves and Plants,* Chapter 9. University of Colorado Boulder. 1-49
Scaling of support costs within the spectrum of leaf physiognomy. *Annals of Botany*, 100, 283–303

Hashmat I., Azad H., and Ahmed A. (2012): Neem (*Azadirachta indica* A. Juss) - A Nature's Drugstore: An overview. *International Research Journal of Biological Sciences*. 1(6), 76-79

Jafari1 S., Saeidnia S., Shams M.R., Ardekani, Hadjiakhoondi1 A. and Khanavi1 M. (2012): Micro morphological and preliminary phytochemical studies of *Azadirachta indica* and *Melia azedarach*. *Turkish Journal of Botany*. 37, 690-697

Kadeba T.O.S. (1993): *Basic Principles of Forestry and Agroforestry*. Forestry handbook. 32pp

Kelly, S.A., Panhuis, T.M. and Stoehr, A.M. (2012): Phenotypic Plasticity: Molecular Mechanisms and Adaptive Significance. *American Physiological Society. Comprehensive Physiology*, 2, 1417-1439

Lazic, M.M., Carretero, M.A., Crnobrnja-Isailovic, J. and Kaliontzopoulou, A. (2015): Effects of Environmental Disturbance on Phenotypic Variation: An Integrated Assessment of Canalization, Developmental Stability, Modularity, and Allometry in Lizard Head Shape. *America Society of Naturalists*, 185(1), 44-58

Lovett, P.N. and Haq, N. (2000): Diversity of the sheanut tree (*Vitellaria paradoxa* C.F. Gaertn.) in Ghana. *Genetic Resources and Crop Evolution*, 47, 293-304

Miner, B.G., Sultan, S.E, Morgan, S.G., Padilla, D.K. and Relyea, A.R. (2005): Ecological consequences of phenotypic plasticity. *TRENDS in Ecology and Evolution*, 20(12), 685-692

Monica G. (2005): Threatened, Endangered and Vulnerable Tree Species: A Comparison between FRA 2005 and the IUCN Red List. Global Forest Resources Assessment. 18pp

Mohammed D., Kwaghe P. V., Abdulsalam B., Aliyu H. S. and Dahiru B. (2014): Review of Farm Level Adaptation Strategies to Climate Change in Africa. *Greener Journal of Agronomy, Forestry and Horticulture*. 2 (2), 038-043

Nicotra, A.B., Atkin, O.K., Bonser, S.P., Davidson, A.M., Finnegan, E.J., Mathesius, U., Poot, P., Purugganan, M.D., Richards C.L., Valladares, F. and vanKleunen, M. (2010): Plant phenotypic plasticity in a changing climate. *Trends in plant science*, 15, 684-692

Niinemets, U., Portsmuth, A., Tena, D., Tobias, M., Matesanz, S. and Valladares, F. (2007) Do we underestimate the importance of leaf size in plant economics? Disproportional scaling of support costs within the spectrum of leaf physiognomy. *Annals of Botany*, 100, 283–303

Pickup, M., Westoby, M. and Basden A. (2005): Dry mass costs of deploying leaf area in relation to leaf size. *Functional Ecology*, 19, 88–97

Reed T.E., Schindler D.E., and Waples R.S. (2010): Interacting Effects of Phenotypic Plasticity and Evolution on Population Persistence in a Changing Climate. *Conservation Biology*, 25, (1), 56–63

Valladares F., Gianoli E. and Gómez J.M. (2007): Ecological limits to plant phenotypic plasticity. *New phytologist*, 176, 749–763

Wiens J.A, Stralberga D, Jongsomjita D, Howella C.A, and Snyder M.A (2009): Niches, models, and climate change: Assessing the assumptions and uncertainties. *Proceeding of the National Academy of Sciences (PNAS)*, 106(2), 19729–19736

Wright, I.J. and Westoby, M. (1999): Differences in seedling growth behavior among species: Trait correlations across species, and trait shifts along nutrient compared to rainfall gradients. *Journal of Ecology*, 87, 85-97

Xu, F., Guo, W., Xu, W., Wei, Y. and Wang, R. (2009): Leaf morphology correlates with water and light availability: What consequences for simple and compound leaves? *Natural Science*, 19, 1789–1798

Yates, M.J., Anthony Verboom, G., Rebelo, A.G. and Cramer, M.D. (2010): Ecophysiological significance of leaf size variation in Proteaceae from the Cape Floristic Region. *Functional Ecology*, 24, 485-492

Soil Remineralization Potential of Rock Dust for Drought Resistance in Obafeni-Owode and Odeda Local Government Areas of Ogun State, Nigeria

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ABSTRACT

This study examined and analyzed the composition of rock dust from five quarries in Obafemi and Odeda LGA of Ogun State, Nigeria for drought resistance. The rock dust samples were analyzed for five mineral elements and these are Calcium, Copper, Lead, Magnesium and Sodium. The result showed that manganese (Mn) had the highest concentration out of the entire element, with the average values ranging from 22.1685 mg/L for PZ Quarry. Magnesium was the second highest in values to manganese in all quarries. The value for magnesium ranged from 5.5317 in OBAT to 6.5756 mg/L in PZ. Sodium was the third highest in concentration ranging from 4.1509 in G.N.S to 6.4686 mg/L in CAPITAL. Calcium was the fourth in concentrations with the average values ranging from 0.8311 mg/L in FAN Quarry to 1.86 mg/L in PZ. Copper was next with the average values from 0.0552 mg/L in FAN to 1.6895 mg/L in PZ. The concentration of Lead (Pb) was generally low in all the Quarries varying between 0.0013 mg/L in FAN and 0.0627 mg/L in G.N.S.

Keywords: Soil remineralization, rock dust, human health, soil fertility, carbon sequestration

INTRODUCTION

Remineralizing forests makes trees more drought resistant, and can prevent forest fires as well it generally strengthens plants and trees, making them less susceptible to diseases, insects and climate change. Unhealthy plants and trees give off carbon dioxide to the atmosphere, while healthy plants store carbon. (organicconnectmag.com/project/why-rock-dust-is-the-futureofgardening.)
Remineralization of the world's soils and forests will propagate carbon sinks, thereby absorbing carbon dioxide from the atmosphere - and overall, contributing to climatic stability. By assuming the task of remineralizing the Earth's soils, much as the glaciers do during an Ice Age, we can create fertile soils and re-create Eden (dev.remineralization.org/soil-remineralization-and-the-climate) Plants growing on mineral-depleted soil do not get enough nourishment and so become smaller, less-abundant and less hardy, more vulnerable to the insects, worms and fungi that prey upon them. (dev.remineralization.org/soil-remineralization-and-the-climate). The results of long term experiments released in 1986 showed that in a forest where pine seedlings were remineralized, after 24 years the wood volume was four times higher than in the untreated area.
(www.foodforthoughtstore.com/wpcontent/upload/2012/03/remineralizedtheearth). Remineralization trials of a dying forest on Mt. Mitchell by Dr. Robert Bruck, Ph.D., showed that twelve weeks after application of rock dust, height of growth of red spruce was increased by 27% over non-treated controls, and height growth of Fraser fir was 19% greater than the untreated controls. (dev.remineralize.org/2007/11/soil-remineralization-and-the-climate/).Long term experiments released in 1986 in Europe showed that in a forest where pine seedlings were remineralized, after 24 years the wood volume was four times higher than in the untreated area.(www.foodforthoughtstore.com/wpcontent/upload/2012/03/remineralizedthe earth). Remineralization can increase yields as much as 2-4 times for crops and 4-10 times for trees. A recent study in Panama showed almost 10 times increased growth for trees planted with a local basalt rock dust. It prevents erosion, and this alone makes it worth applying to conserve the world's soils. We will need much less irrigation and water use because remineralized soils hold more moisture content. (organicconnectmag.com/project/why-rock-dust-is-the-futureofgardening). Rock dusts, also known as rock powders, rock minerals, soil mineralization consist of finely crushed rock processed by natural or mechanical means, containing minerals and trace elements widely used in organic farming (http://en.wikipedia.org/wiki/Rockdust, 2013). Rock dusts contain an extensive range of trace elements beneficial for plant growth. In the late nineteenth century, Julius Hensel in his discussions with the proponents of artificial fertilizers advocated the use of rock dust to improve soil quality and the crop health (Thompkins & Bird, 1989). Some years ago Men of The Trees in Western Australia began work on rock dust, a by-product of the quarrying industry, to see if they could restore our 'non-glacial' soils. The results were astounding. Tree seedlings grew at five times the normal rate in the nursery. When planted out they continued to leap ahead, helping restore degraded farmland in our semi-arid wheat belt.

METHODOLOGY

Study Area

The study was carried out in Odeda and Obafemi Area of Ogun State, selected quarries and there location include, Oba Quarry, at Ika Village, Odeda LGA, PZ Quarry Obafe LGA, Capital Quarry, Olodo, Odeda LGA, FAN Quarry, Baiya, Odeda LGA G.N.S Obafe L.G .For each of the quarries 1 kg of rock dust sample was collected and these were converted to gramme, that is 1000 g of rock sample was collected (1000 g – 1 kg).
Materials: Sieve, Sensitive balance scale, Rock dust collected from different quarries**,** Laboratory test.**,** Sampling bottle, Polythene bag

Method

Rock dust was collected from five different quarries around Odeda and Obafe LGA. The samples were sieved using 0.063 mm, 0.074 mm, 0.088 mm, and 0.125, This was to determine the different size composition of the rock dust samples and the sample where weight on the sensitive balance scale to get the different weight of the different sizes, rock dust that was sieved with 0.064 mm and 0.074 mm sieve was taking to the laboratory for analysis. The samples were digested using a digesting machine. Two ml of peroxide and 12 ml of 6.25 selenium metal was mixed into 100 ml of concentrated sulphuric acid (H_2SO_4). To each of 10 digesting bottles, 12 ml of the mixture of hydrogen peroxide, selenium metal and concentrated sulphuric acid were put and then 1gram of each rock duct sample was added. The ten numbers of bottles was because the rock duct from each quarry site was replicated. The bottles were arranged in the digesting machine. After digestion the solution was diluted with distilled water up to 100 ml and was kept in sample bottle for proximate analysis

RESULTS AND DISCUSSION

Table 1: Weight of the rock sizes using sieves of 0.063, 0.074, 0.088, 0.125. (g)

QUARRYS	0.063	0.074	0.088	0.125 (g)	particles.
FAN	46.4	8.1	20.6	12.8	912.1
0BAT	17.7	5.2	14.5	18.3	944.3
CAPITAL	13.1	7.3	3.6	3.8	972.2
P.Z	14.8	15.3	5.7	12.3	951.9
G.N.S	33.4	6.2	19.7	15.6	925.1

Source: Field Study, 2013

The results of the proximate analysis are shown on Tables 2-7. Six minerals were tested For, and these are calcium,(Ca) copper,(Cu) magnesium,(Mg) manganese,(Mn) lead,(Pb)sodium (Na)

Table 2: Mineral composition of rock dust from FAN Quarry, Odeda LGA.

Element	Signal Absolvent		Concentration (mg/L)		Average Concentration
	Sample 1	Sample 2	Sample 1	Sample 2	(mg/L)
Calcium (Ca)	0.001	0.020	1.3292	1.5019	0.8311
Copper (Cu)	0.035	0.020	0.6965	0.4081	0.0552
Lead (Pb)	0.000	0.0001	-0.0134	0.0159C*	0.0013
Magnesium	1.017	1.036	5.8610C*	5.9800C*	5.9205
Manganese (Mn)	1.130	1.037	24.243 C*	21.992 C*	23.1178
Sodium (Na)	0.513	0.550	3.9903	4.3115	4.150

Source: Laboratory Analysis, 2013

Table 3: Mineral composition of rock dust from OBAT Quarry, Odeda LGA.

Element	Signal Absolvent		Concentration		Average Concentration
	Sample 1	Sample 2	Sample 1	Sample 2	mg/L
Calcium (Ca)	0.002	0.001	1.6212	1.2398	1.4305
Copper (Cu)	0.064	0.045	1.2876	0.9011	1.0944
Lead (Pb)	0.000	0.0263	0.0220	0.0263	0.0242
Magnesium (Mg)	1.064	0.864	6.1556C*	4.9078C*	5.5317
Manganese (Mn)	1.076	1.148	23.0113C*	24.6841C*	23.8477
Sodium (Na)	0.612	0.597	4.8526	4.7225	4.7741

Source: Field Survey, 2013

Table 4: Mineral composition of rock dust from CAPITALQuarry, Odeda LGA.

Element	Signal Absolvent		Concentration		Average Concentration
	Sample 1	Sample 2	Sample 1	Sample 2	mg/L
Calcium (Ca)	0.001	-0.002	1.2193	1.9929	1.6061
Copper (Cu)	0.032	0.041	0.6523	0.8160	0.7341
Lead (Pb)	-0.002	-0.001	0.0475C*	-0.0202	0.0137
Magnesium (Mg)	0.934	1.225	5.3454C*	7.1549C*	6.2501
Manganese (Mn)	1.057	1.032	22.4660C*	21.872C*	22.169
Sodium (Na)	0.642	0.662	5.1506	5.3516	5.2511

Source: Field Survey, 2013.

Table 5: Mineral composition of rock dust from G.N.S Quarry, Obafe LGA.

Element	Signal Absolvent		Concentration		Average Concentration
	Sample 1	Sample 2	Sample 1	Sample 2	mg/L
Calcium (Ca)	0.001	0.001	1.5088	0.8163	1.1626
Copper (Cu)	0.101	0.068	2.0185	1.3706	1.1625
Lead (Pb)	0.000	0.0003	0.0062	0.1192	0.0627
Magnesium (Mg)	1.198	0.703	6.9884C*	3.9065 C*	5.4474
Manganese (Mn)	1.032	1.099	21.8772C*	23.8772C*	22.8772
Sodium (Na)	0.534	0.918	4.1698	8.7675 C*	6.4686

Source: Field Survey, 2013

Table 6: Mineral composition of rock dust from PZQuarry, Obafe LGA.

Element	Signal Absolvent		Concentration		Average Concentration
	Sample 1	Sample 2	Sample 1	Sample 2	mg/L
Calcium (Ca)	0.001	0.002	1.1556	2.2235	1.6896
Copper (Cu)	0.049	0.063	0.9880	1.2610	1.6895
Lead (Pb)	0.001	0.002	0.0337	0.0513	0.0425
Magnesium (Mg)	0.842	1.422	4.7711C*	8.3801C*	6.5756
Manganese (Mn)	1.131	1.146	24.3531C*	24.6286C*	24.4909
Sodium (Na)	0.498	0.571	3.8366	4.4904	4.1635

Source: Field Survey, 2013

Table 7: Summary of the average concentration (mg/L) of analyzed minerals in rock dust Quarries

Mineral Elements	FAN	OBAT	CAPITAL	G.N.S	PZ
1. Calcium (Ca)	0.8311	1.4305	1.6061	1.1626	1.6896
2. Copper (Cu)	0.0552	1.0944	0.7341	1.1625	1.6895
3. Lead (Pb)	0.0013	0.0242	0.0137	0.0627	0.0425
4. Magnesium (Mg)	5.9205	5.5317	6.2501	5.4474	6.5756
5. Manganese (Mn)	23.1178	23.8477	22.169	22.8772	24.491
6. Sodium (Na)	4.1509	4.7741	5.2511	6.4686	4.1635

Source: Field Survey, 2013

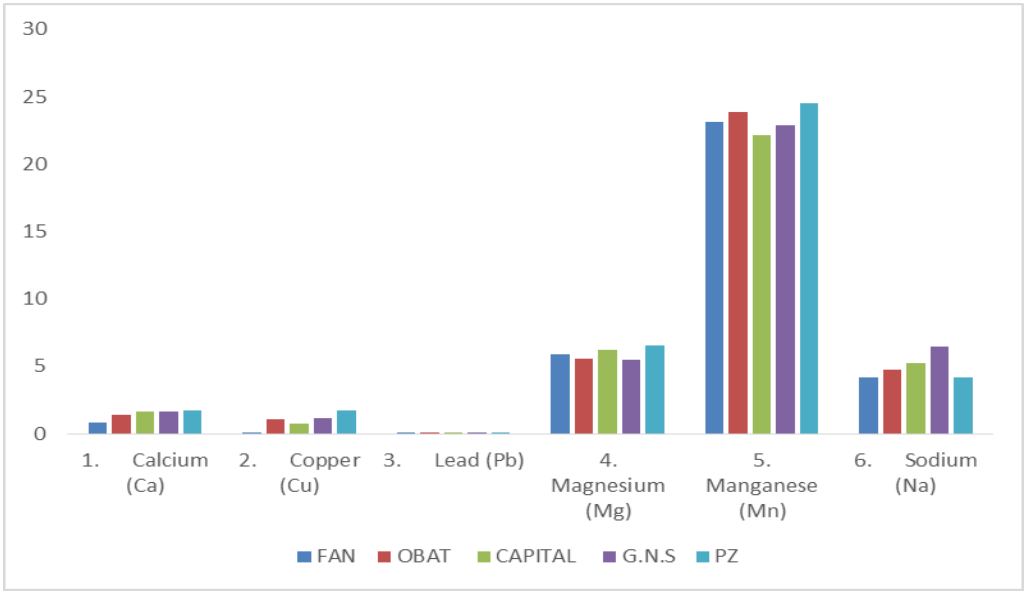


Figure 1: Histogram showing the summary of average concentration of analyzed minerals in rock dusts sampled in the study areas

DISCUSSION

Table1 showed the weight of the different rock dust sizes after it had been sieved using sieve of 0.063 mm, 0.074 mm, 0.088 mm and 0.125 mm, respectively, From table one FAN QUARRY has the highest quantity for rock dust size with sieve of 0.063, which weigh 46.4 g on a sensitive scale, follow by sieve of 0.088 which weigh 20.8 g next to it 0.125 which weigh 12.8 g and the smallest is sieve of 0.074 which the weight of 8.1 g. OBAT QUARRY has the height quantity for rock dust size with sieve of 0.125 which weigh 18.1 g on a sensitive scale, follow by sieve of 0.063 which weigh 17.7 g next to it 0.088 which weigh 14.5 g and the smallest is sieve of 0.074 which the weight of 5.2g. CAPITAL QUARRY has the height quantity for rock dust size with sieve of 0.063, which weigh 13.1 g on a sensitive scale, follow by sieve of 0.074 which weigh 7.3 g next to it 0.125 which weigh 3.8 g and the smallest is sieve of 0.074 which the weight of 3.6 g. P.Z QUARRY has the height quantity for rock dust size with sieve of 0.074 which weigh 15.3 g on a sensitive scale, follow by sieve of 0.063 which weigh 14.8 g next to it 0.125 which weigh 12.3 g and the smallest is sieve of 0.088 which the weight of 5.7 g. G.N.S QUARRY has the height quantity for rock dust size with sieve of 0.063, which weigh 33.4 g on a sensitive scale, follow by sieve of 0.088 which weigh 19.7g next to it 0.125 which weigh 15.6 g and the smallest is sieve of 0.074 which the weight of 6.2 g

Table 2: From the mineral composition tables i.e. tables 2-5, Sample 1 indicates rock dust that was sieved with 0.064mm sieve while sample 2 was sieved with 0.074mm sieve. The signal absolvent determined the concentration, the higher the signal absolvent the higher the concentration, e.g. from table **2** the signal absolvent of Calcium (Ca) for **Sample 1** is 0.001 and the concentration is 1.3292, while the signal absolvent for Calcium for **Sample 2** is 0.022 and the concentration is 1.5019. This is also applicable to the other minerals tested for in other quarries. The result showed that the mineral were present in different concentration in the rock dust sample.. Also those Concentration with **C*** indicates that the concentration is higher than the standard

$$\textbf{Average Concentration} = \frac{\text{concentration of sample 1 + concentration of sample 2}}{\mathbf{2}}$$

Table 3 showed the mineral composition of rock dust from Fan quarry Odeda LGA, Ogun State, The table indicates that Manganese (Mn) has the highest concentration with an average value of 23.1178 while Lead (Pb) with an average concentration of 0.0013, Lead (Pb) has the lowest concentration in all the minerals analyzed at FAN quarry.

Table 4 showed the mineral composition of rock dust from Obat Quarry, Odeda LGA, Ogun State, The table indicates that Manganese (Mn) has the highest concentration with an average value of 23.8477 while Lead (Pb) with an average concentration of 0.0242, Lead (Pb) has the lowest concentration in all the minerals analyzed at OBAT Quarry.

Table 5 showed the mineral composition of rock dust from Capital Quarry, Odeda LGA, Ogun state. The table indicates that Manganese (Mn) has the highest concentration with an average value of 22.196 while Lead (Pb) with an average concentration of 0.0137, Lead (Pb) has the lowest concentration in all the minerals analyzed at CAPITAL Quarry.

Table 6 showed the mineral composition of rock dust from GNS Quarry, Obafe Local Government Area, Ogun state, The table indicates that Manganese (Mn) has the highest concentration with an average value of 22.8772 while Lead (Pb) with an average concentration of 0.0627, Lead (Pb) has the lowest concentration in all the minerals analyzed at G.N.S Quarry.

Table 7 showed the mineral composition of rock dust from PZ Quarry, Obafe Local Government Area, Ogun state; the table indicates that Manganese (Mn) has the highest concentration with an average value of 24.4909 while Lead (Pb) with an average concentration of 0.0425, Lead (Pb) has the lowest concentration in all the minerals analyzed at PZ Quarry.

Figure 1 showed the Average Mineral Concentration for each element analyzed for in all the Quarries. From this table, it can be deduced that Manganese (Mn) has the highest concentration **Pz Quarry** is the quarry with the highest concentration of Manganese (Mn) with an average value of 24.4909 followed by **Obat Quarry** with an average value of 23.8477, next is **FAN Quarry** with an average value of 23.1178, GNS Quarry with an average value of 22.8772 and lastly **CAPITAL Quarry** with an average value of 22.169 while Lead (Pb) is the only mineral that has the lowest concentration out of all the elements analyzed from the quarries, from the table, **FAN Quarry** has the lowest concentration of Lead (Pb) with an average value of 0.0013, followed by **CAPITAL Quarry** with an average value of 0.0137, next is **OBAT Quarry** with an average value of 0.0242, **PZ Quarry** with an average value of 0.0425 and lastly GNS with an average value of 0.0627. G.N.S Quarry has the highest concentration of sodium (Na) with an average value of 6.4686, next to it is the CAPITAL Quarry with an average value of 5.2511, next to it is the OBAT Quarry with an average value of 4.7741, next to it is the PZ Quarry with an average value of 4.1635 and the lowest is the FAN Quarry with an average concentration of 4.1509. PZ Quarry has the highest concentration of copper (Cu) with an average value of 1.6895, next toit is the CAPITAL Quarry with an average value of 1.1625, next to it is the OBAT Quarry with an average value of 1.0944, next to it is the G.N.S Quarry with an average value of 0.7341, and the lowest is the FAN Quarry with an average value of 0.0552. PZ Quarry has the highest concentration of magnesium (Mg) with an average value of 6.5756, next to it is the CAPITAL Quarry with an average value of 6.2507, next toit is the FAN Quarry with an average value of 5.9205, next to it is the OBAT Quarry with an average value of 5.5317 and the lowest is the G.N.S Quarry with an average value of 5.4474. PZ Quarry has the highest

concentration of calcium (Ca) with an average value of 1.6896, next to it is the CAPITAL Quarry with an average value of 1.6061, next to it is the OBAT Quarry with an average value of 1.4305, next to it is the G.N.S Quarry with an average value of 1.1626, and the lowest is the FAN Quarry with an average value of 0.08311.

CONCLUSION

Rock dust available in one study area contain nutrient element that are useful for plant growth and production. Magnesium, Manganese and Sodium are in abundant. Judging by their concentration in all sample analyzed.

REFERENCES

David, Y.(2006):Re-mineralizeorg/blog/magazine/from-chenobly-to-japen-treating- radiation-sickness-with rock dust. From Chernobyl to japen. Assesed 09/25/2012http://en.wikipedia.org/wiki/Rockdust, (June, 2013). Assessed 09/25/2012

John H, Don Weaver, Larry E, Joam A Campe: (dev.remineralization.org/soil.remineralization- and-theclimate).Assessed 09/25/2012

John H, Don Weaver, Larry E, Joam A Campe 2007: Soil Remineralization and the climate. (dev.Remineralize.org/2007/11/soil-remineralization-and-the-climate/) Assessed 09/25/2012

Organic connection natural vitality's journal of calmful livings: (organicconnectmag.com/project/why-rock-dust-is-the-futureofgardening.) Assessed 11/25/2012

Thompkins, P. & Bird, C., 1989: *Secrets of the Soils*, Penguin Books, England

Vonu.Sauter, K.Foerst(1986): Application of silicate Rock dust for the Amelioration of forest soils. (www.foodforthoughtstore.com/wp-content/upload/2012/03/remineralizedtheearth) Assessed 9/25/2012

Microbial Evaluation of *Pakia biglobosa* Parts and Soils in Savanah Region from Different Provenances in West Africa

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ABSTRACT

Pakia biglobosa known as african locust beans is an important tree which occur in natural and semi-natural habitats such as savannah. The seed is rich in protein when fermented , the stem and leaf are highly medicinal and the wood a useful source of coal and timber. The incidentce of microbial pathogen could be a threat to the survival of this all important tree hence the need to evaluate the microbial flora of its bark, leaf and soil. Different bacteria genera which include the Entobacteriacae, Bacilli and Streptococci species were isolated from the soil. Fungi genera isolated include; Aspergillus totalling 46.66% out of which are soil sapropytes while others such as A.niger, A.flavus, A.fumigatus, A.tamari, A.terreus and Fusarium sp. with 13.82% present are not only pathogenic but can be mycotoxigenic. Botryopilodia sp. have the highest occurrence among isolates from both P.biglobosa parts and infected twig parts which is a pointer for die back incidence on the plantation.

Keywords: *Pakia biglobosa*, soils, microbial flora, incidence

INTRODUCTION

Pakia biglobosa belongs to the genus *Pakia*, family fabaceae, it consists of about 35 species but five other well recognized species besides African locust bean include *Parkia filicoidea*, *P. bicolor*, *P. roxburghii*, *P. biglandulosa* and *P. madagascariensis* (Keay, 1989). It occurs in the natural and semi-natural habitats such as savannah and woodlands, sometimes on rocky slopes, stony ridges and sandstone hills. It is able to withstand drought because of its deep taproot (Builders *et. al*., 2014). Commonly known as African locust beans together with shea butter. *Vittelaria paradoxa* is one of the main components of agro forestry parklands in West Africa (Shao, 2002). In West Africa the bark, roots, leaves, flowers, fruits and seeds are commonly used in traditional medicine to treat a wide diversity of complaints, both internally and externally, sometimes in combination with other medicinal plants. The bark is most important for medicinal uses, followed by the leaves. Medicinal applications include the treatment of parasitic infections, circulatory system disorders, such as arterial hypertension, and disorders of the respiratory system, digestive system and skin. In veterinary medicine, a root decoction is used to treat coccidiosis in poultry. Green pods are crushed and added to rivers to kill fish. Geographically, *Parkia biglobosa* can be found in a belt stretching from the Atlantic coast in Senegal to southern Sudan and northern Uganda. The tree currently exists within a wide range of natural communities but is most abundant in anthropic communities – places where cultivation is semi-permanent. Annual production of seeds in northern Nigeria is estimated at around 200 000t. While the products of the tree are not common in international trade, they form an important part of local and regional trade in West Africa. The seeds are especially prized, and much trade occurs locally in the Sahel region where they are transferred between borders. Seeds are fermented to make dawadawa: a black, strong – smelling tasty food rich in protein. The yellow starchy pulp that surrounds the seed is an important food supplement rich in vitamin C and carbohydrates. The dried powder is often mixed with water to produce a drink called dozim. The food products collected from *P. biglobosa* are especially important due to the seasonality of fruit maturation and food availability (Shao, 2002 and Abbiw, 1990). Branches of *P.biglobosa* are sometimes lopped for firewood, attract bees and a popular tree among beekeepers. Pods and root are used as sponges and strings for musical instrument. Its wood are used for timber, pulps for alcohol, tannin or dyestuff, gum or resin, barks and pods contain piscicides which contain alkaloid parkin which is poisonous (Builder *et. al*., 2014). The bark is used as mouthwash , cure toothache and other skin and gastrointestinal disease.

Parkia biglobosa is known with some insects, small rodents and livestock which may damage the seedlings but seedlings survive easily and the leaves are quickly replaced. Weevil and the pyraid moth have been observed on the fruits, moth eats both the pulp and seed, the leaves are attack by Lepidoptera families and timber is readily attack by termites, marine borers and fungi complexes. Today's forest management decisions integrate increasingly complex and changing social, economic, and ecological values. Foresters not only are concerned with the basic silvicultural goals of harvesting and regeneration but also seek to sustain long-term productivity of forest sites, protect non timber resources such as water and scenery, and maintain biodiversity. All this requires understanding of how forest ecosystems function. Today, forestry and forest sciences are shifting dramatically from basing decisions on how trees operate to a holistic integration of how all the parts of a forest work together, how they are linked and interdependent.

Fungi diseases are serious problem in forest regeneration and sometimes fungi can cause heavy mortality in nurseries .Fungi attack cause discoloration and cosiderably reduce the value of the wood. Non-timber forest products derived from *P. biglobosa* such as food, medicine, animal fodder, soil amendments, charcoal, and firewood (Chandrasekharan, 1993) enhance the need to protect the regenaration of the plant. The microbial evaluation of plantations is necesssary to prevent pathogenic invasion which may lead to total loss of important tree species. Hence the study aim to carry out microbial evaluation of the soils, leaf, stem and bark of *P. biglobosa* for the presence of associated microbes.

MATERIALS AND METHOD

Isolation and Identification of Associated Microbes on *P. biglobosa* Soils and Parts

Samples of plantation soils, leaves and bark of *P. biglobosa* were collected from eight provenaces: Nigeria, Mali, Senegal, Burkina Faso, Guinea, Cameroun, Benin Republic and Ghana of *P. biglobosa* established at Wasengari, Saki, Oyo State, Nigeria. All samples were aseptically collected, stored in a sterile transparent Zip loc sample bags and isolation was made in the laboratory within 48 hours of collection. The plant parts in each provenace were sectioned into smaller pieces using a sterile scalpel, surface sterilized in 10% sodium hypochlorite and blotted dry in between sterile Whatman No 1 filter paper. Serial dilutions to 10^{-3} dilution factor of soil sample in each provenace was done to assay microbial flora in the soil. Potato dextrose agar (PDA), Nutrient agar (NA), and MacConkey agar were routinely prepared in the laboratory, autoclaved at 121^{o}C for 15minutes. The media were allowed to cooled to about 45^{o}C, dispensed into a sterile Petri dish and left to set on the bench. The plant part tissues and 1 ml of soil dilution (10^{-3}) were separately inoculated onto the media (Pitt *et. al*., 1995), PDA was used for mycoflora assay and incubated at room temperature 28$\pm$2^{o}C for 5 – 7 days. NA and MacConkey agar were used for bacteria assay and incubated for 24 – 48 hours. Microbial colonies from the soil and plant parts in each medium were counted depending on when growth occurred, frequency of occurence of colonies and morphological appearance were observed. Pure cultures of associated fungi were obtained by subculture on fresh PDA. Morphological appearances were used to identify the fungi with reference to identification keys by Kulwant *et al.*, 1991 and Raper and Fernnel, 1965. Bacteria colonies were subculture on fresh NA for Gram staining and microscopic examination and on MacConkey agar to observe for the presence of Gram negative, lactose and weak lactose fermenting bacteria genera present.

RESULTS AND DISCUSSION

Microbial Count of *P. biglobosa* soil across Provenances

Many bacteria belonging to different genera were isolated from soils of *P. biglobosa*, the microbial load and occurrences showed that *P. biglobosa* from Senegal has the highest number ($5.7x10^3$ cfu/ml) of bacteria load and Ghana *P. biglobosa* recorded the least of $2.7x10^3$ cfu/ml. Mali soil has $4.7x\ 10^4$ cfu/ml as the highest fungi colony while Burkina Faso has the least at $1.8x\ 10^4$ cfu/ml as presented in table 1.

Table 1: Microbial Count of *P. biglobosa* Soil across Provenances

Provenances	Fungi colony (cfu/ml) $x10^4$	Bacteria colony (cfu/ml) $x10^4$
Nigeria	1.9	35
Mali	2.4	29
Burkina faso	1.8	23
Senegal	4.7	57
Cameroun	1.9	44
Benin	3.0	46
Guinea	2.7	37
Ghana	2.1	27

Fungi from varied genera were isolated from *P. biglobosa* soils indicating a similar trend to that obtained with bacteria load whereby *P. biglobosa* from Senegal also have the highest number of fungi colony with $4.7\ x10^3$ cfu/ml but Burkina Faso showed least fungi load of $1.8x10^3$ cfu/ml (Table 1). *Entobacteriacae*, *Bacilli* and *Streptococci* species were isolated from *P. biglobosa* soils in the provenances. *Bacillus* spp. such as *Bacillus thuringensis*, *B. mycoides* and even the waxy appearance of *B. cereus* were part of the isolates. Also are *Streptococci*, *Diplococccci*, and *Staphylococci* cultured from the soils of *P. biglobosa* across the provenances as shown in Table 2. Different fungal genera were isolated from *P. biglobosa*; *Aspergillus* genera dominating with total of 69.86% which includes *A .niger, A.versicolor, A. flavus, A. fumigatus, A. tamari, A. terreus* and other Aspergillus sp. which are either saprophytic pathogenic and could even be mycotoxigenic. Others are *Fusarium sp.* 27.71% , *Rhizopus sp* 8.43%, *Botryoplodia sp.* 1.02%, *Pythium sp.* 3.61%, *Trichoderma sp*. 1.20% and *Penicllium sp.* 1.20% were the fungi present in the soil as shown in Table 3. The bark and leaves of *P.biglobosa* were assayed for fungi colony by direct plating on PDA as shown in table 4 below. The bark and leaves of *P.biglobosa* known for its high medicinal use is colonized by pathogenic fungi such as *Botryopilodia sp*. 44.44% and 27.78% occurence respectively along with other pathogens as presented in the Table 4.

Table 2: Bacteria in *P. biglobosa* Soil

Provenanace	*Enterobacter* spp.	*P.vulgaris*	*Salmonella* spp.	*S. mercesem*	*K. pneumoniae*	*Bacillus* spp.	*Streptococcus* spp.	*Staphylococus* spp.	*Diplococcus* spp.
Nigeria	+	+	-	-	-	+	-	-	-
Mali	+	+	+	-	-	+	-	-	-
Burkina faso	+	+	-	+	+	-	-	-	-
Senegal	+	+	+	-	-	+	+	+	-
Cameroun	+	+	+	-	+	+	+	-	-
Benin	+	-	-	-	-	+	-	-	-
Guinea	+	+	-	-	-	-	-	-	+
Ghana	+	-	-	-	-	+	-	-	-

Table 3: Percentage of Occurrence of Fungi in *P.biglobosa* Soil

Provenance	*A.niger*	*A.versicolor*	*A.lilanus*	*A.flavus*	*A.fumigatus*	*A.tamaris*	*A.terreus*	*A. spp.*	*Penicillium* spp.	*Fusarium spp.*	*Trichoderma sp.*	*Pythium* spp.	*Botyro* spp.	*Rhizopus* spp.	% occurence of fungi across provenances
Nigeria	+	+	+	-	-	-	-	+	-	+	+	+	-	+	57.14
Mali	+	+	-	-	-	+	-	+	-	+	-	-	-	+	42.86
Burkina faso	+	-	-	-	+	-	+	+	-	+	-	+	-	-	42.86
Senegal	+	+	-	-	-	+	+	+	-	-	-	-	-	-	35.71
Cameroun	-	-	-	-	-	-	-	-	-	+	-	-	-	+	14.29
Benin	+	-	+	+	+	-	-	+	-	+	-	-	+	+	57.14
Guinea	+	-	-	-	+	+	-	+	+	+	-	-	-	+	50.00
Ghana	-	-	-	-	+	-	+	+	-	+	-	-	-	+	35.71
% Occurence of organisms	12.04	7.23	6.02	1.20	9.64	10.84	6.02	16.87	1.20	27.71	1.20	3.61	1.02	8.43	

Table 4 : Fungi isolates from *P.biglobosa* bark and leaf

Provenanace	*Botryopilodiasp.*		*A.niger*		*A.flavus*		*A.fumigatus*		*A.sp*		*Fusarium sp.*		*F.verticillioides*		*Pestolatia sp.*		*Penicilliu m sp.*		*Trichoderma sp*		*Bipolaris sp*		Occurence of fungi across Provenance	
	Bark	*Leaf*	*Bark*	*Leaf*	*Bark*	*Leaf*	*Bark*	*Leaf*	*Bark*	*Leaf*	*Bark*	*Leaf*	*Bark*	*Leaf*	*Bark*	*leaf*	*Bark*	*Leaf*	Bark	Leaf	Bark	leaf	Bark	Leaf
Nigeria	+	+	-	-	-	-	-	-	-	-	+	-	-	+	+	-	-	-	-	-	-	+	50	42.86
Mali	+	+	-	-	-	-	-	-	+	-	-	+	-	+	+	-	-	-	-	-	-	-	37.5	42.86
Burkina faso	+	+	+	-	+	-	-	-	-	-	-	-	-	-	+	-	-	+	-	-	-	+	50	50.00
Senegal	-	-	-	-	-	-	-	+	-	-	-	+	-	-	+	+	-	-	+	-	-	+	37.5	71.43
Cameroun	+	+	-	-	-	-	-	-	-	-	-	+	-	-	+	+	-	-	-	-	-	+	25	71.43
Benin	+	+	-	-	-	-	-	-	-	-	-	-	-	+	+	-	+	-	-	-	-	+	37.5	42.86
Guinea	+	+	+	-	-	-	-	-	+	-	-	-	-	+	-	-	+	-	-	-	-	-	50	28.57
Ghana	+	+	-	-	-	-	-	-	-	-	-	+	-	-	+	-	-	-	-	-	-	+	12.5	42.86
% Occurence	44.44	27.78	8.33	-	2.78	-	-	2.78	5.56	-	2.78	16.67	-	13.89	22.22	8.33	5.56	2.78	2.78	-	-	22.22		

Some areas in the P.biglobosa palntation show obvious level of disease incidience as a result of stem or twig infection which lead to total loss of the plant leaving space within the plantation. Infected twig with dark smoky head samples were taken from Senegal, Guinea and Mali and were assayed in the laboratory for the associated organisms the result were as presented in table 5 below.

Table 5 : Fungi isolates from infected twig/stem of P.biglobosa

Provenanace	*Botryopilodia* spp.	*Fusarium* spp.	*A.niger*	*Pestolatia* spp.
Mali	+	+	-	+
Senegal	+	+	+	-
Guinea	+	+	+	+
% Occurence	50	18.5	12.5	31.25

The need to assayed infected twig was as a result of incidence of disease acros the provenance which leave part of the plant devoid of any growth. Generally assessment was back with laboratory analysis as *Botryopilodia sp* isolated with the highest occurence is known for dieback in cashew florescence and also result to root and stem rot in *P.biglobosa* with obvious symptom of smoky twig. The asssayed stem confirm *Botryopilodia sp* with 50% occurrence as the highest occured pathogen follow by Pestolatia. All the four isolates are know to be pthogenic fungi while the high incidence of *Botryopilodia sp* can be a pointer of die back disease in *P.biglobosa* young tree.

CONCLUSION AND RECOMMENDATIONS

From the arrays of organisms isolated from this study it can be deduce that despite the antimicrobial potential of *P.biglobosa* as a plant , *Parkia biglobosa* could be attacked by various fungi and bacteria which could lead to die back or total death of the tree, if it is exposed to pathogenic or opportunistic pathogenic invasion both in soil and on its part. There is the need for constant evaluation and maintanence of the plantation to keep the plants and maintain its existence because of the usefulness as source of protein, timber and also medicinal capabilities.

REFERENCES

Bonkougou, E. G, Djimde M, Ayuk E.T, Zougrana I, Tchoundjeu, Z. 1999**.** The market potential of parkland trees:Agroforestry Today. 11(1-2):13-15.

Kutama, A. S., Saratu, A.O. and Asma'U, A. 2012. occurrence of wood-and root- rot basidiomycetes on trees in Bayero University, Kano, Nigeria. Bayero Journal of Pure and Applied Sciences, 5(2): 26 – 30 *Bajopas Volume 5 Number 2*

Kutama, A. S. 2011: Fungi and the services they render to man and the Ecosystem. The green world magazine. Maiden edition. Pp 07 – 08.

Builders, M. I., 2014. **P**arkia Biglobosa (African Locust Bean Tree) World Journal of Pharmaceutical Research Vol 3, Issue 2; 1672-1682.

Pitt, J. I., Hocking, A.D., Samson , R. A. & King . A. D., 1992. Recommended methods for mycological examination of foods, 1992. In modern methods in food mycology pp.365-368. Edited by R.A. Samson, A.D. Hockings, J. I Pitt & A.d. King. Amsterdam: Elservier

Kulwant,S. J., Frisvad, U.T and Mathur, S.B.,1991**.** An Illustrated Manual on Identification of some seed-borne Aspergilli, Fusaria , Penicilia and their mycotoxin. Institute if seed pathology and department of Biotechnology Denmark. ISBN87-7026-3175. Pp: 31-122

Shao M . 2002. Parkia biglobosa. Changes in resources allocated in Kandiga, Ghana. Master Thesis, Michigan Technologist University, United state of American,.Abbiw DK. Useful Plants of Ghana. Intermediate Technology Publications and the Royal Botanic Gardens, Kew, UK, Britain: 1990, p.337

Keay RWJ 1989. Trees of Nigeria. Oxford University Press, New York:, p.476.

Chandrasekharan C. 1993. Issues involved in the sustainable development of non-wood forestproducts. Paper prepared for the expert consultation on non-wood forest products for English-speaking African countries. Arusha, Tanzania, Rai and Mamatna,2005

Raper, K.B and Fernnel D.L., 1965. Introduction to food –borne fungi. Edited by A.Samson and Ellen Hooekstra(CBS).

Tree Growth Characteristics and Stem Taper for *Triplochiton scleroxylon* (K. schum) Stands in Ibadan Metropolis, Nigeria

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ABSTRACT

Dearth of periodic and current information on forest stand has been greatly acknowledged in Nigeria. This study was carried out to assess the relationship between stem taper and tree growth parameters for Triplochiton scleroxylon stands in Ibadan metropolis, Nigeria. Taper is the changing diameter of a tree part over its length. Four age stands of T. scleroxylon trees were used for the study with a minimum of four temporary sample plots of size 20m by 20m randomly established in each of the stand established in the year 1973, 1974, 1975 and 1976. The temporary plots in 1973, 1974 and 1975 were located in Onigambari Forest Reserve while the plot 1976 was located in the arboretum of Forestry Research Institute of Nigeria. Stratified random sampling technique was adopted and data collected within each plot included Diameter at breast height (Dbh), diameter at the base (D_b), middle (D_m) and top of the trees (D_t), total and merchantable height and crown depth. Individual tree basal area and stem volume were estimated using their respective empirical formula. Two variants of stem taper, TAP^1 (defined as the ratio of tree diameter at the top to the diameter at the base) and TAP^2 (defined as the ratio of diameter at breast height to tree total height) were computed and tested against various tree attributes. The quantitative data collected were subjected to descriptive analysis, one way ANOVA and correlation analyses. The results of the investigation showed that TAP^2 was significant while TAP^1 was not significant when tested across the different stand ages with 1976 stand having minimum mean value of 21.91 ± 5.98 and 1975 stands with maximum mean value of 28.70 ± 9.25. The result showed that the majority of the trees are of good taper, although the plot located within Forestry Research Institute of Nigeria showed a better taper form compare to those located within the reserves. However, it is recommended that permanent sample plots be established for regular and consistent data collection

Keywords: Stem taper, *Triplochiton scleroxylon*, tree growth characteristics

INTRODUCTION

Tree growth follows many mechanical rules to assure survival. In order to prevent concentrating force at weak points, tree growth distributes loads and compensates for relatively weaker locations by adding more woody materials. One critical element of sustaining strength and stiffness is the amount of taper developed. Stem taper can be defined as the relative rate of change in stem diameter with increasing height; this change is a natural trend for the species and can be expressed using a mathematical function (Sintia, *et al*; 2016). Within each portion of a tree, stem, branch or twig, taper rate changes. Taper is the degree to which a tree's stem or bole decreases in diameter as a function of height above ground, unlike slenderness coefficient which is the ratio of tree total height (THT) to diameter outside bark at 1.3m or 4.5ft above the ground level. Trees with a high degree of taper are said to have poor form, while those with low taper have good form. Taper varies with species, diameter at breast height and size (Lewis *et al*, 2005); also varies throughout age as a natural developmental phenomenon or results from phases of relative competition with neighboring trees (Larson 1963, Finger *et al*, 1995).

Recently, the study on stem taper is becoming significant in quantitative forestry following the susceptibility of many economic tree species to natural phenomenon such as wind damage, snap, blow down, breaking or uprooting of live tree as a result of high intensity of wind components. Many researchers have shown that taper is the principal factor affecting the susceptibility of a tree to wind damage (Laiho 1987; Lohmander and Helles 1987; and Petty and Swain 1985). However, in Nigeria, the tropical rainforest ecosystem is a major source of timber supply to the wood industries (Akindele, 2002). The tropical rainforest ecosystem contain several indigenous tropical hardwood species of economic value which include *Khaya Spp, Triplochiton scleroxylon, Milicia excels* etc. (Akindele, 2002). The forest is renewable natural resources which require effective scientific management. The forest manager like any other resource manager requires reliable information of the current state of the standing timber in the forest in terms of its yield, growth, quality, quantity, size and location of the forest resources available and how these resources are changing over time. This information leads to the knowledge about the growth and development of the forest stand which is considered important in forestry as it provides clues to the future behaviour and guide to the management of a given stand and also helps the manager in decision making about the forest stand.

According to Wang *et al.* (1998), the susceptibility of a stand to wind throw or damage is largely influenced by the tree taper of the tree and this vulnerability to wind most times is based on a combination of some tree growth characteristics, stand conditions, site soil and site quality, topography and wind patterns (Ruel, 2000). These combinations generally substantiate the impact of both biological and physical factors on the individual tree or stand stability among exotic species (Byrne, 2011; Nivert, 2001; Navratil, 1996).Though several studies and results had been carried out and recorded on taper and stand stability potential in many part of the world (Rudnicki *et al*., 2004; Wang *et al* ., 1998; Liu *et al* ., 2003; Becquey and Nivert, (1987), the study on stem taper with reference to its relationship with the tree growth characteristics have not been researched in Nigeria. However, the current climate changes with series of environmental degradation and desert encroachment in the tropics including Nigeria necessitate critical assessment of the relationship between stem taper and Tree Growth Characteristics in Nigeria as it relates to evaluation of stand stability of *Triplochiton* spp in Nigeria. However, Onyekwelu (2001) reported that little emphasis has been given to growth characteristics of many species in Nigeria and where silvicultural intervention had been adopted without good knowledge of growth characteristics, bad management decision are always made with attendance adverse effect on stand productivity. Therefore, this study explored the relationship between tree stem taper and tree growth characteristics for *T. scleroxylon* plantations in Onigambari forest reserve and FRIN arboretum, Nigeria.

MATERIALS AND METHODS

Data Collection and Procedure

Four age series stands of *Triplochiton scleroxylon* plantations were used (34, 35, 36 and 37years old). The 34, 35 and 36yrs old plantations were located within the Onigambari Forest Reserve while the 37yrs old was located in Forestry Research Institute of Nigeria arboretum. A total of 24 temporary sample plots of size 20m by 20m were located and enumerated considering the sizes of the stands. Stratified Random Sampling Technique was used for carrying out this study. In each of the age series, 4 to 6 temporary sample plots were established and enumerated. Measurement taken and recorded included Diameter at breast height of all trees (cm), diameter at the base, middle and top of all trees (cm), crown depth and diameter of all trees, total and merchantable heights of all trees(m). Since an uneven aged stand may be defined as a stand containing groups of trees of varying ages with rather complicated development patterns (Smith *et al*, 1997), age and size distributions indicated that all study stands could be defined as uneven aged.

Table 1. Descriptive statistics of measured tree DBH and Height for the *Triplochiton scleroxylon* stands

Age (years)	**N**	**DBH** (cm)			**Height** (m)		
			Mn	**SD**		**Mn**	**SD**
37	59	(*13.27–36.70*)	24.97	6.40	(*5.00 – 29.80*)	20.66	5.63
36	65	(*11.30 - 39.88*)	22.54	6.89	(*3.80 – 28.70*)	17.26	6.09
35	52	(*11.30 – 50.95*)	28.70	9.25	(*6.80 – 57.50*)	18.80	7.48
34	80	(*10.95 – 38.10*)	21.91	5.98	(*3.80 – 30.80*)	17.79	5.88

N= number of trees with measured DBH and Height values; Mn= Mean; SD= Standard Deviation
Values in parentheses are the minimum and maximum of the variable

Data Processing and Analysis

One way analysis of variance (CRD) was used to test for differences among the stand ages in terms of stem tapers. Product moment correlation analysis (Pearson Correlation Coefficient) was used to evaluate the association between the stem tapers computed and other tree growth characteristics. The data collected were processed into suitable form for statistical analysis as follows:

Basal Area

The Basal Area for individual trees within each plot were estimated using;

$$\text{Basal Area} = \pi D^2/4$$

where, BA = Basal Area (m^2), π = 3.142 (constant), D = diameter at breast height (m).

Stem Volume

The Stem Volume of individual trees within each plot was estimated using the processed Newton's formula:

$$\text{Stem Volume} = \pi h/24(D_b^2 + 4D_m^2 + D_t^2)$$

where V= stem volume of individual tree (m^2), π = 3.142 (constant), h =Merchantable height (m), D_b= diameter at the base (m), D_m= diameter at the middle, D_t =diameter at the top (m)

Stem Taper Computation

Two variants of stem taper computed for evaluation in this study were:

*Stem Taper1 (**Tap^1**)* = D_t/D_b and *Stem Taper 2 (**Tap^2**) = DBH/THT*

where D_t =diameter at the top (m), D_b= diameter at the base (m), DBH= Diameter at breast height, THT = Total height of the tree.

RESULTS AND DISCUSSION

RESULTS

Table 2: Results of Analysis of Variance (ANOVA) across the different stand ages

Sources of variation		df	Sum of Square	Mean of Square	F- ratio	Sig
Tap^2	Stand age	3	36.929	12.310	3.584	0.014*
	Error	252	865.477	3.434		
	Total	255	902.406			
Tap^1	Stand age	3	0.021	0.007	0.951	0.417ns
	Error	252	1.860	0.007		
	Total	255	1.881			

* Significant difference at P<0.05, ns: Not significant

Table 3: Correlation Coefficient between the Stem Taper and Tree Variables

Tree Variables	**Tap^1**	**Tap^2**
Age	0.30	0.43
Diameter at Breast height	0.020	0.130*
Tree height	-0.680	0.494
Crown diameter	-0.043	-0.030
Crown length	-0.34	-0.42
Basal Area	0.019	0.151*
Stem Volume	-0.214	-0.122

DISCUSSION

The result of ANOVA above showed that stem taper (tap^1) when assessed across the different stand ages was not significant (0.417) at the probability level of 0.05 while stem taper (tap^2) was found to be significant (0.014) at probability level of 0.05 (Table 2). Thus, tap^2 has a significant effect when assessed across the stand ages. That is, there are significant differences between the stand ages but the exact pairs of stand ages that are different were not known. However, the result of follow up test carried out (test of means) showed that stand age 37 years with mean value (5.0503) was significantly different from stand ages 36 and 34 years with mean values of 4.1970 and 3.9871 respectively while not significantly different from stand age 33 years with mean value of 4.5582 (table 2). Moreover, the difference observed in stand age 37 years and other stand ages might be due to difference in location (site), plot composition (number of trees per plot) and different maintenance practices given to the stand.

However, the result of the correlation coefficient between the two stem tapers and tree diameter at breast height (DBH) was found to be positive and stem taper (tap^1) was found to be negative with the tree height while stem taper (tap^2) was found to be positive (Table 3). This result indicates that stem taper of *Triplochiton scleroxylon* stands studied tend to increase with increase in diameter; stem taper (tap^1) revealed a decrease as tree height increases while stem taper (tap^2) revealed an increase in stem taper as the tree height increases (Table 3). Also, the correlation coefficient between stem taper and tree height was higher than the correlation coefficient between stem taper and other tree attributes. This result was similar to result obtained by Konopka *et al*, (1987) which indicated that taper was negatively correlated with tree crown width for Norway spruce *Picea abies* (L.). This indicates that tree height is a better function that can be used in estimating stem taper for *Triplochiton scleroxylon* stands studied than the tree diameter. This result was similar to the result obtained by Onilude *et al*, (2012). Furthermore, crown depth, crown diameter and stem volume were found to be negatively correlated with stem taper while basal area was found to be positively correlated. The results confirm that stem taper values for the studied stands decreases with increasing crown depth and crown diameter.

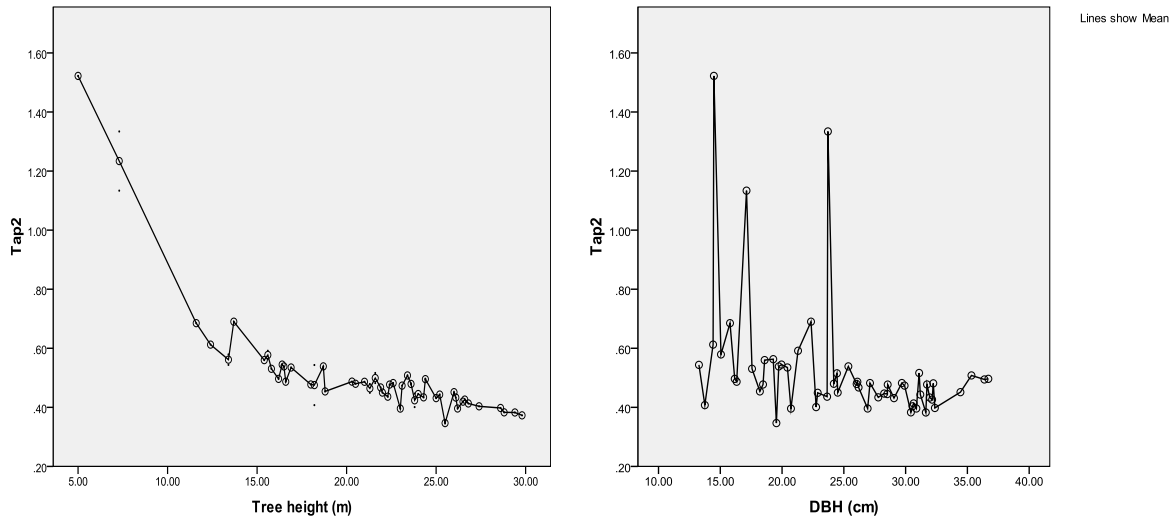


Figure 2a: Stem tapers agianst tree height and dbh for age 37 years old stand

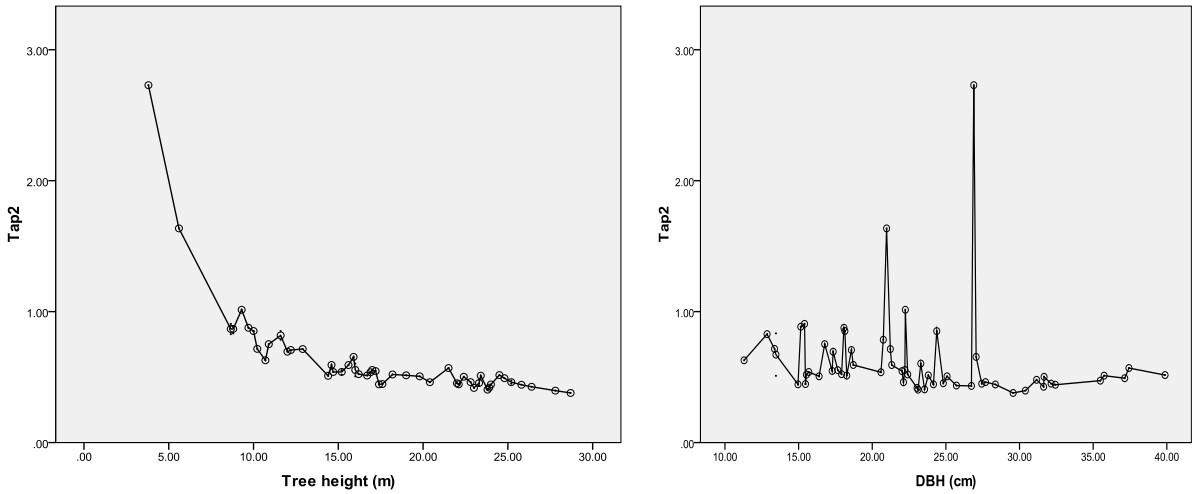


Figure 2b: Stem tapers agianst tree height and dbh for age 36 years old stand

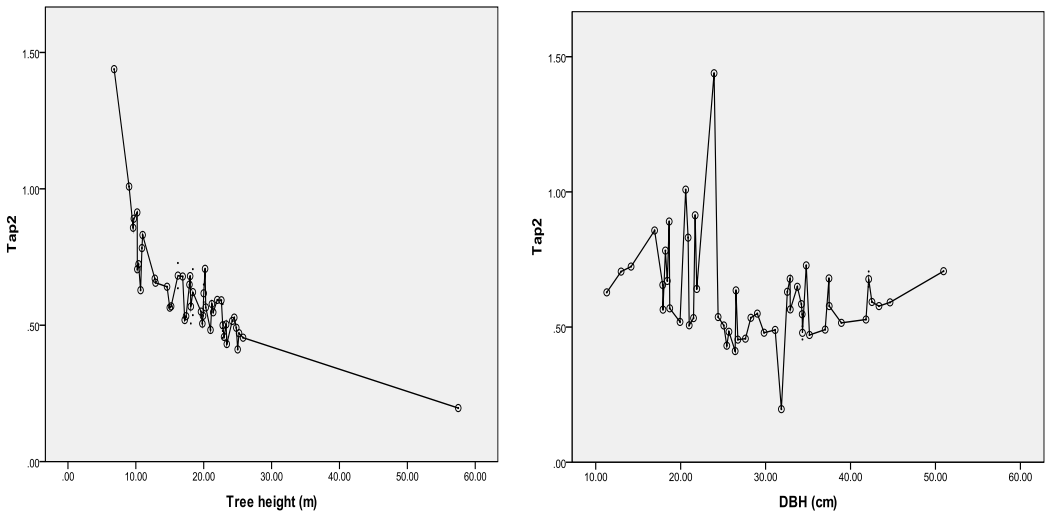


Figure 2c: Stem tapers agianst tree height and dbh for age 35 years old stand

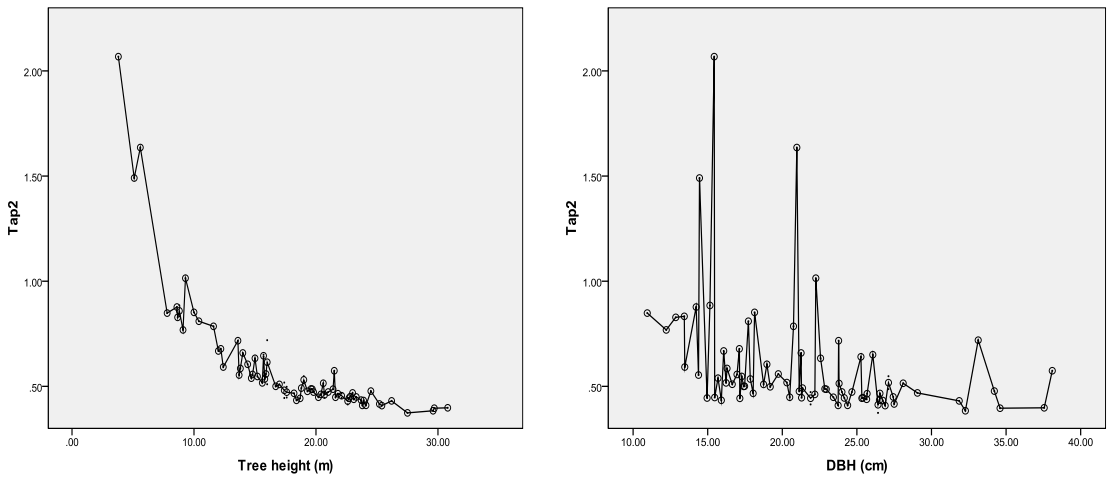


Figure 2d: Stem tapers agianst tree height and dbh for age 34 years old stand

CONCLUSSION

The relationship between stem taper and tree growth characteristics for *Triplochiton scleroxylon* have been established. Trees with a high degree of taper are said to have poor form, while those with low taper have good form. However, tree DBH and tree height are the two key predictors that determine the stem taper of *Triplochiton scleroxylon* species. For this study, the majority of the *Triplochiton scleroxylon* trees found in all the stands have a good form. However, the stands located at the Forestry Research Institute of Nigeria arboretum has a better form compare to those located in the reserves. This may be due to the adequate and proper forest management practices given to the stands in the research institute arboretum, difference in plot composition and also, in soil characteristics. The result of this study indicates that stem taper of *Triplochiton scleroxylon* stands studied tend to increase with increase in diameter; stem taper (tap^1) revealed a decrease as tree height increases while stem taper (tap^2) revealed an increase in stem taper as the tree height increases. Also, the study showed that tree height is a better function that can be used in estimating stem taper for *Triplochiton scleroxylon*.

RECOMMENDATION

The study however, recommended that, since the study made use of temporary sample plots, permanent sample plots be established within the various reserves for regular and consistent data collection and also to ensure continuity of provision of growth data for management purposes. In addition, more attention and security should be given to the few stands of *Triplochiton scleroxylon* species remaining in this reserve to ensure more researches are being done.

REFERENCES

Akindele, S. O. (2002): Weibull Distribution Model for *Nauclea diderrichii* in Omo Forest Reserve, Nigeria. *Nigerian Journal of Forestry* 32 (2): 56-61.

Finger, C.A.G (1995): Funcoes de forma para Eucalyptus dunnii implantados na depressao central e encosta sudoeste do Rio Grande do Sul. Ciencia Rural, Santa Maria, v.25, n.3, p.399-403, 1995. Available from: <http://www.scielo.br/scielo.php.

Koehler, S.V; Koehler, H.S; Figueiredo, F.A; Arce; J.E; and Machado, S.A (2016): Evolution of tree stem taper in *pinus taeda* stands. *Ciencia Rural, Santa Maria*, v.46, n.7,p.1185-1191, July, 2016.

Konokpa, J; Petras, R; and Toma, R **1987**. Slenderness coefficient of the major tree species and its importance for static stability of stands. Lesnictvi (Prague), 33:887- 904.

Laiho, O. (1987): Susceptibility of Forest stands to windthrow in Southern Finland, Fol. For. (Helsinki) No. 706 pp. 23-24.

Larson, P.R (1963): Stem form development of forest trees. Washington: Forest Science Monograph,1963. P. 1-41.

Lewis, J; Kenneth, B; Raysouter, R; and Daniels F. (2005): Parisimonious and completely compatible taper, total and merchantable volume Models. *Journal of Forest Research.*

Lohmander, P and Helles F. (1987): Windthrow probability as a function of stand characteristics and shelter. Scand. *J. For. Res.* 2: 227-238.

Onilude Q.A and Adesoye, P. O (2007). Relationships between tree slenderness coefficient and tree growth characteristics for *Triplochiton scleroxylon* (k. schum) stands in Ibadan Metropolis, Nigeria. *Obeche Journal* vol. 25 (2) June 2007:16-24.

Onilude, Q. A; Julius, A. J; Olaiwola, B. I; Showunmi, I. L and Ogunremi, O. C (2012)**.** Relationship between Canopy Width, Tree Height, Trunk Size and Slenderness Coefficient of Four Tree Species Growing in Ibadan Metropolis, Oyo State, Nigeria. *International Journal of Applied Research and Technology.* 1(3): 98-105.

Petty, J. A. and Swain, C. (1985). Factors influencing stem breakage in high winds. *Forestry* 58:75-84.

Somade, A. F. (2000): Effects of period of seed harvest on germination, storage, biochemical composition and early seedling growth of *Mansonia altissima*. Ph.D Thesis, University of Ibadan, Ibadan.

The Role of Insect Museum in Biodiversity Conservation

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ABSTRACT

Nigeria, like most of the countries in the tropics is a treasure trove of insect diversity; however, limited information is available on the taxonomy, ecology, genetics and biogeography of its insect fauna. This dearth of background scientific knowledge impedes successful insect conservation policy and practice. This review identifies the key challenges to insect diversity conservation in Nigerian ecosystems. This study however, reviewed Nigerian insects, beneficial roles of forest insects as well as method of insect collection. Challenges of insect conservation in Nigeria and sustainable management practices/strategies were highlighted.

Keywords: Treasure trove, insect diversity, biogeography

INTRODUCTION

The protection of forest from damage is a basic practice in forestry. Among the destructive agents insect rank higher with fire, diseases and wind. Many kinds of insects are constantly at work in the forest and cause a steady drain on timber supplies. A relatively few species of insect periodically become endemic and kill forest trees on extensive areas, causing serious economic losses. Insects play a major role in forest ecosystem, which can be either destructive or constructive in nature depending on the value system we use in judging their activities. Forest insects are considered to be those that inhabit forests and related areas, including urban areas causing serious damages and injuries to forest trees while on the other hand support tree growth and development. The emphasis is upon damaging insects of forest trees such as the leaves eater, the stem borers and those forming galls on the leaves as well as stem.

Museum of insects worldwide house an estimated 3 billion preserved specimens together with their collective data. This represents an immense knowledge base of global biodiversity (Ownes and Duin, 2008). Museum specimens, particularly well-represented taxa such as butterflies and beetles, can provide us with data for investigating the effects of climate change, habitat modification and loss due to anthropogenic activity and the resulting distributional changes over time, often spanning many decades. Although many historic specimens housed in museums and private collections will be unsuitable for molecular research (due to their age, methods of preparation or preservation) there are still many that can provide scientists with valuable data (Mark Colvin, 2014). Within biodiversity research, taxonomists and evolutionary biologists are the traditional users of insect museum. But the result of their work is only one part of these collections' value. For environmental research, agriculture, genomics, climate studies, epidemiology, ecological niche modeling for conservation, public health, and many other areas of research, collections have become indispensible (Mark Colvin, 2014).



Plate 1: Arrangement of Insect boxes in the Museum.

There has been no consistent approach to the conservation of insects in Nigeria and several gaps are still to be filled in terms of research and management strategies that can support conservation of this important group of organisms in the country (Kehinde *et al*, 2014). The current trend of poor inventory of insect fauna in the nation may imply that several species would be lost before they are ever accounted for.

Urgent action is needed to embark on extensive inventories that will lead to the discovery of new species as well as provide distribution and abundance data of insects in the different vegetation zones within the country. This will provide base line information that can be used in conservation planning as well as in modelling response to ecologically important scenarios like climate change, agriculture, tourism etc. Plate 1 showing a research scientist displaying insect boxes where various species of dried insect were kept for insect taxonomy and preservation.

NIGERIAN INSECTS

Insects are habitat-specific in nature and as a result, they are highly sensitive to disturbance, particularly habitat fragmentation (Aizen and Feinsinger 2002; Ashworth *et al.* 2004). Most forest insects have narrow geographical range of distribution, often nearly endemic in a particular biogeographic forest type (Spitzer *et al*. 1993). Modifications of the natural environment as a result of sustained human activity will affect the relative abundance of species and in extreme cases lead to extinction of certain species (Groombridge 1992). Several studies from different parts of the world have provided evidence to support the view that deforestation and other forms of habitat disturbance can cause a reduction in insect abundance and species richness (Holloway *et al,* 1992 in Borneo; Eggleton *et al,* 1995, &1996 in Cameroon; Watt *et al,* 1997 in Cameroon; Kitching *et al,* 2000 in Australia; Ricketts *et al,* 2002 in Costa Rica and Aderolu *et al,* 2014 in Nigeria). These studies brought about a general consensus in the field of insect conservation that the most important factor in maintaining diversity is maintaining appropriate habitat (Pullin 1995).

However, our understanding of the impact of deforestation and other anthropogenic activities on insect species richness and abundance in Nigerian forests is poor due to lack of or inadequate published information. Although, appreciable attempts have been made to quantify the impact of deforestation on global species extinction, resulting in estimates of global species extinction rates of 1-10% species per decade (Reid 1992). These estimates have all been obtained by extrapolating from known relationships between species richness and habitat area. Despite the fact that insects account for the greatest amount of biodiversity in forests, they are the least studied of all fauna (Cardoso *et al*. 2011; Zou *et al.* 2011). Published research on the impact of tropical forest management practices on insects is currently limited to individual species (Eggleton *et al.* 1995, 1996; Estrada and Fernandez 1999; Davis *et al*. 2001).

NIGERIAN FORESTS AND DEFORESTATION

Forests serve as reservoir of biodiversity and serve as recreation and tourism centers. Invertebrates account for the greatest amount of biodiversity in forest ecosystems. Invertebrates (especially insects) dominate among multicellular organisms in forests in terms of richness, abundance and biomass (Erwin *et al.* 2004). A careful study of the vegetation of Nigeria shows that true and protected forest is mainly found in the southern part of the country and it occupied 93,345 km in 1993 (9.6 % of the total land area of the country). This area increased to 11.4 % in 1994 but dropped to 10 % in 1995 (CBN 2001). Conservation efforts have led to the establishment of game reserves and protected ecosystems in some parts of the country, especially in the northern savannah e.g. Yankari in Bauchi state, Borgu in Niger State and the old Oyo National Park in Oyo state just to mention a few. Deforestation is a serious threat in Nigeria which currently has one of the highest rates of forest loss in the world. Since 1990, the country has lost some 6.1million hectares or 35.7% of its forest covers (FAO 2000).

According to the revised deforestation figures from FAO (2005), between 1990 and 2005, Nigeria lost a staggering 79% of its forests and since 2000, the country has been losing an average of 11% of its primary forests per year - double the rate of the 1990s. Intensive farming methods are among the primary causes of habitat destruction in Nigeria as it is characterized by vegetation destruction and landscape fragmentation. Large scale plantation establishment of cash crops as well as indiscriminate bush burning and overgrazing lead to habitat destruction with consequent impact on insect species (Emma-Okafo*et al.* 2010). At present, the destruction of natural habitats in Nigeria continues apace resulting in the depletion of the country's biodiversity (Imeht and Adebobola 2001). Every year, a considerable part of the nation's forest resources is destroyed through industrialization, urbanization, road construction, commercial agriculture and otheractivities thereby disturbing the ecological balancethat nature maintains with living and non-living resources (Imeht and Adebobola 2001).

BENEFICIAL ROLES OF FOREST INSECTS

1. Pollinators;
2. Food;
3. Act as natural enemies

A number of economic important forest insects have been recognized through a continuous survey conducted throughout the geographic zones of the country. These include gregarious pests of economic importance such as *Hypsipylarobusta; Phytolymaspp; Chlorophora excelsa; Analeptestrifasciata; Orygmophoramedioforeat* (Anderson, 1979).

METHODS OF INSECT COLLECTION

Collection of forest insects is found effective in the morning before sunrise as it is sometimes very impossible to trap forest insects at sunrise due to heat energy that might drive them away or increase their activity rate. Some insects were handpicked while some were trapped using sweep net. A soft bodied insect is collected by dipping in a kilner jar containing soaked cotton wool (ethyl acetate) with filter paper on top while hard bodied insects are collected in the absence of chemical (dry collection). Then, the trapped insects in the kilner jars will be taken to the laboratory for identification, preservation, and then display along with the host plants.

Insects collected through wet collection are always oven dried under a very low temperature of about greater than or equal to 5^{o}C. The trapped forest insects will then be pinned on the setting board with the wings stretched out and lay dorsally for display. The dried specimens will then be transferred into the museum insect boxes with attached label containing the scientific name of specimen, site of location, name of collector, host plant on which the insect was found and date of collection (as it was shown below in Plate 2a and 2b).



Plate 2a and 2b: The display of insect pests in insect boxes

EXAMPLES OF CASES OF INSECT COLLECTION AT FRIN

Table 1: Taxonomic classification of Insect species collected at FRIN Nursery

Scientific names	Common names	Family	Order
Chrysolagriacuprina	Beetles	Lagridae	Coleotera
Zonocerusvariegatus	Grasshopper	Acrididae	Orthoptera
Apismellifera	Bees	Apidae	Hymenoptera
Orygmophoramedioforeata		Acrididae	Orthoptera
Vespulaspp	Wasps	Vespidae	Hymenoptera
Anoplocnemiscurvipes	Coreid bug	Coreidae	Hemiptera
Brachytrupedesmembranaceus	Cricket	Acrididae	Orthoptera
Oothecamutabilis	Beetles	Galerucidae	Coleoptera

The Orders of these insects in Table 1 which are Coleoptera, Orthoptera and Hymenoptera are the most damaging of the commonly encountered defoliators according to Chamberlin, 1989. One year of severe damage done to the forest by defoliators may be enough to kill some forest trees. Reports also showed that these insects cause retard growth and yield of affected trees (Chamberlin, 1989).

CHALLENGES OF INSECT CONSERVATION IN NIGERIA

Insect conservation is facing several challenges in Nigeria. Sustainable biodiversity conservation of insects cannot proceed without addressing the following challenges according to Kehinde *et al*, 2014.

Taxonomic challenge

A few insect species have scientific names in Nigeria. About 20% of all insect species found in Nigeria have been catalogued by Medler (1980); others are yet to be identified. Many insects need identification, taxonomic revisions, and many species, even common ones, have multispecies complexes which are sibling species, morphospecies or convergent evolutionary species. In short, the vast majority of insects remain unknown and getting them described before they go extinct, is the taxonomic challenge. Insect taxonomists are very few in Nigeria, and may not be up to ten (10) in numbers (kehinde *et al*, 2014). There is therefore an urgent need for mass training of insect taxonomists who will collect, preserve and identify insect specimens.

Ecological challenge

In addition to inadequate taxonomic knowledge, the ecological knowledge of Nigerian insects is poorly understood. The distribution and abundance of many species in the country are unknown while the ecosystem services associated with them are mostly assumed. Not knowing what species contribute to what ecosystem services means that the full consequences of species extinctions are extremely hard to predict (Kozlowski 2008). Anthropogenic effect on insect diversity is known only for a limited number of species (Kozlowski 2008).

Human exploration and Conservation conflict

Conflicts between conservation and human needs have hampered efforts to prevent biodiversity loss in Nigeria. Areas of high conservation value are now characterized by high human population density, high agricultural productivity, road construction and industrialization (Andrew *et al.* 2001). Conservation centers are opened up to meet up with the increasing societal demands. Conservation and developmental needs must be reconciled in Nigeria so that efforts of past conservationists are not wasted.

INSECT CONSERVATION STRATEGIES

- Inclusion of insect identification methods in the biology curriculum of secondary school students in Nigeria would assist in the training of amateur entomologists who will become proficient in the description of species.
- There is also the need to develop cybertaxonomy and biodiversity informatics in order to provide efficient and universal access to species lists, distribution databases and ecological data in Nigeria.
- A timely engagement of practitioners in these conservation related disciplines is needed to estimate how much genetic, species, community, biotope and ecosystem diversity are available and at what rate they are being lost and to give possible directives on how to arrest declines (Samways 1993).
- For insects in particular, a good understanding of the spatio-temporal distribution of insect diversity is essential for effective conservation strategies (Lewis and Baset 2007).
- Researchers should also be supported to attract foreign grants that will complement funds that are available locally to drive goal oriented projects in this field.

CONCLUSION

Sustainable action towards efficient insect conservation/ museum has been described. Critical investigation of the ecology of insects in Nigerian ecosystems approached from both the insect taxon and habitat perspectives should precede conservation management decisions. Germane considerations that take into account the needs and limitations of various taxa such as food, nesting sites, habitat pollution and fragmentation will proffer valuable insight for sustainable management of insect communities. The achievement of efficient insect conservation towards biodiversity conservation lies on the ability of all stake holders in research institutions and academic institutions to partner with one another and adopt a holistic resource conserving research frame work that will reduce biological and ecological degradation in the environment. All practices that endanger the diverse species of insects must be discontinued.

REFERENCES

Aderolu, I. A; Omooloye, A. A; Okelana, F. A (2014): Occurrence, Abundance and Control of the major insect pests associated with Amaranthus in Ibadan, Nigeria. EntomolOrnitholHerpetol 2:112.doi.10.4172/2161- 0983.1000112.

Aizen, M. A, Feinsinger, P. (2002): Bees not to be?Responses of insect pollinator faunas and flower pollination to habitat fragmentation. In: Bradshaw G. A.,Mooney H. A., (ed). *How landscapes change: human disturbance and ecosystem fragmentation in the Americas*. Springer-Verlag. pp. 111-129.

Anderson, N. H., Sedell, J. R. (1979): Detritus processing by macro-invertebrates in some ecosystems. *Annual Review of Entomology* 24:357-377.

Andrew, B, Joslin, L. M., Thomas, B., Neil, B., Louis, A. H., Paul, W, Carsten, R. (2001): Conservation conflicts across Africa. *Science, New Series* 291: 2616-2619.

Ashworth, L, Aguilar, R. L., Galetto L, Aizen, M. A.(2004): Why do pollination generalist and specialist plant species show similar reproductive susceptibility to habitat fragmentation? *Journal of Ecology* 92: 717-719.

Cardoso, P., Erwin, T. L., Borges, A. V., Paulo, T. R. (2011): The seven impediments in invertebrate conservation and how to overcome them. *Biological Conservation* 144:2647-2655.

Central Bank of Nigeria(2001).*Annual Report and Statement of Account* for the Year ended 31 December 2001 pp.142.

Colvin, M. (2014): *Entomological Collections - Their Historic Importance and Relevance in the 21st Century* [Online].Available fromhttp://www.dispar.org/reference.php?id=92 [Accessed December 28, 2014].

Davis, A. J., Holloway, J. D., Huijbregts, H., Krikken J., Kirk-Spriggs, A. H., Sutton, S. L. (2001):Dung beetles as indicators of change in the forests of northern Borneo. *Journal of Applied Ecology* 38: 593 616.

Eggleton, P., Bignell, D. E., Sands, W. A., Waite B.,Wood, T. G., Lawton, J. H. (1995): The species richness of termites (Isoptera)under differing levels of forestdisturbance in the Mbalmayo Forest Reserve, southern Cameroon. *Journal of Tropical Ecology* 11: 85-98.

Eggleton, P., Bignell, D. E., Sands W. A., Mawdsley, N. A., Lawton, J. H., Bignell, N. C. (1996). The diversity, abundance and biomass of termites under differing levels of disturbance in the Mbalmayo Forest Reserve, southern Cameroon . *Philosophical Transactions of the Royal Society of London Series B-Biological Sciences* 351: 51 68.

Emma-Okafor L. C., Ibeawuchi I. I., Obiefuna J. C.(2010). Biodiversity Conservation for sustainable agriculture in tropical rainforest of Nigeria. *New York ScienceJournal* 3: 82-88.

Estrada, C., Fernandez, F. (1999). Diversity of ants (Hymenoptera: Formicidae) in successional gradient of a cloud Forest (Narino, Colombia) *Revista de Biologia Tropical* 47: 189-201.

Food and Agriculture Organization (2000).*Global Forest Resources Assessment*. FAO paper. Available from http://www.fao.org/docrep/004/y1997e/y1997e00.htm (accessed August 2014).

Food and Agricultural Organization (2005).Towards sustainable forest management.Available from www.mongabay.com (accessed August 2012).

Groombridge, B. (1992). *Global Biodiversity: status of theearth's living resources.* Chapman and Hall.London.

Holloway, J. D., Kirk-Spriggs, A. H., Chey V. K.(1992). The response of some rain forest insect groups to logging and conversion toplantation. In: Marshall A. G., Swaine M.D., (ed.) Tropical Rain Forest: Disturbance and Recovery. *Philosophical Transactions of the Royal Society* Alden Press, Royal Society .pp. 425 436.

Imeht, N., Adebobola, N. (2001). The effects of poverty in conservation of Biodiversity: The Nigeria Experience. Available at http : / / w ww. s c i e n c e i n a f r i c a . c o. 2 0(accessed August 2012).

Kitching, R. L, Orr, A. G., Thalib, L., Mitchell, H., Hopkins, M. S., Graham, A. W. (2000). Moth assemblages as indicators of environmental quality of Australian rain forest. *Journal of Applied Ecology* 37: 284 -297

Kozlowski G. (2008). Is the global conservation status assessment of a threatened taxon a utopia? *Biodiversity and Conservation* 17: 445-448.

Leiws, O. T, Baset, Y. (2007). Insect conservation in tropical forests. In: Stewart AJA, New TR, Lewis OT, (ed.) *Insect Conservation Biology.* The Royal Entomological Society. pp. 34-56.

Pullin, A. S. (1995).*Ecology and Conservation of butterflies*. Chapman and Hall, London pp.363.

Reid, W. V. (1992). How many species will there be?In: Whitmore, T. C. and Sayer, J. A., (eds.) *Tropical Deforestation and Species Extinction.* Chapman and Hall. pp. 55-73.

Ricketts, T. H., Aily, G. C. D., Hrlichh, P. R. E. (2002).Does butterfly diversity predict moth diversity? Testing a popular indicator taxo nat local scales. *Biological Conservation* 103:361-370.

Samways, M. J. (1993). Insects in biodiversity conservation: some perspectives and directives. *Biodiversity Conservation* 2: 258282.

Spitzer, K., Novotny, V., Tonner, M., Leps J. (1993).Habitat preferences, distribution and seasonality of the butterflies (Lepidoptera:Papilionoidea) in a montane tropical rainforest Vietnam. *Journal of Biogeography* 20:109-121.

Watt, A.D; Stork N.E; Eggleton, P; Srivastava, D; Bolton, B; Larsen, T. B and Brendell, M. D (1997): Impact of forest loss and regeneration on insect abundance and diversity. In: Watt A. D., Stork N. E.,Hunter M. D.,(eds.) *Forests and Insects* .Chapman and Hall. pp. 274-286.

Zou, Y., Feng ,J., Xue, D., Sang, W., Axmacher, J. (2011).Insect Diversity: Addressing an Important but strongly neglected research topic in China. *Journal of Resources and Ecology* 2:380- 384.

The Effects of Growth Hormones on the Vegetative Propagation of *Piper umbellatum*

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ABSTRACT

Piper umbellatum exists seasonally as an undomesticated and undergrowth plant of the rain forest vegetation that plays important roles as local vegetable and medicinal plant. This study is therefore important as a result of limited research on this plant and the effect of growth hormones on this species in Nigeria which has not been established. The research was conducted in Ibadan, Nigeria. This comprises of forest survey of Piper umbellatum and a nursery experiment in Forestry Research Institute of Nigeria (FRIN) and setting of cuttings in rooting hormones in top soil media. Three main plant growth hormones, Indole-3-butyric acid (IBA), Gibberellic acid (GA) and Naphthalene Acetic acid (NAA) at two different levels (50ppm and 100ppm for each of the hormones) were used. The effects of the three hormones on vegetative propagation and growth of Piper umbellatum were evaluated. Plant growth characteristics across the treatments were significantly higher in plant hormone treatments ($p \leq 0.05$) than in untreated plants, in most cases. NAA performed best, followed by IBA and GA while control that was without the application of plant hormones was the least in terms of plant growth. Treatment hormone levels of 50ppm were not significantly higher in terms of Piper umbellatum sprouting and growth improvement. Percentage sprouting for 100ppm is 37%, 32%, 17% and 14% for NAA, IBA, control and GA respectively, thus NAA performed best. The nodal position for obtaining the best performance of Piper umbellatum cuttings is the basal node. Assessment of growth parameters established that plant hormones used in the study have the potential of improving plant growth. Therefore, Piper umbellatum could be raised using hormones at 100ppm on the basal node and government extension effort should be intensified to domesticate and conserve Piper umbellatum while propagating the species with appropriate methods.

Keywords: *Piper umbellatum*, growth hormones, vegetative propagation

INTRODUCTION

Plants are essential components for human development and sources of food and fibre. Some non-timber products derived from forests include tree latex, edible fruits and nuts. Many of forest trees are the main medicinal and ornamental plants now used by vast majority of rural and even urban populace across the nation (Okafor, 1980). Several of these plants such as *Piper umbellatum* that occur in wild state or in traditional farming system of Nigeria humid tropic are traditional source of food. Such foods are also available at strategic seasons of the year when the conventional food items are scarce Canadian International Development Agency (C.I.D.A), 1992). *Piper umbellatum* (Linn) otherwise known as umbelled pepper is typically aromatic and the leaf is also eaten raw or cooked as a seasoning. The root is a warm, active remedy against poison and in many parts of sugar colonies made into syrup much used by the inhabitants for cold and catarrh. The *Piper* species importance includes its uses as vermifuge, antiscorbutic, diuretic and prevention against infections (Food and Agricultural Organisation (F.A.O), 1986; Hutching, 1986).

Vegetative propagation has become increasingly popular for the propagation of plant species with difficult seeds. Seed propagation remains the principal mode of propagation in agriculture in the temperate as well as in the tropical region. Seeds are usually produced in large numbers and are readily available, each year or at longer intervals (Osameobo, 1993). Several chemical compounds promote seed germination. Some compounds interact with the physiological mechanisms of some seed may result in dormancy types. Pretreatment application may break or relieve dormancy for example, partly substitute for temperature and light pretreatment, or for leaching of germination inhibitors. Some compounds stimulate individual metabolic process during germination without being directly linked to dormancy. The effect of germination stimulant is often most evident under sub-optimal germination temperature. Total germination speed and seedling vigour may be promoted by the application of germination stimulant (Salomon, 1988). In the early thirties, there was throughout the world, a proliferation of independent studies concerning the effects of natural and synthetic growth substances on root initiation. There have since been reports describing the use of grain in stimulating rooting. Thimann (1936) discovered that auxins stimulate rooting of cuttings. Thimann and Koepli (1935) identified one of the active growth promoting substances as Indole Acetic acid (IAA). Thus, the three main plant growth

hormones at two different levels were used in this study are Indole-3-butyric acid (IBA), Gibberellic acid (GA) and Naphthalene Acetic acid (NAA).

The tropical forest where these plants are found is disappearing as a result of over exploitation and clearance for other uses. Apart from the effect on the tropical environment, this has caused reduction and disappearance of long known indigenous food, leaves, roots and latex (Nwoboshi, 1982). Some of these forest trees and non-tree species that are disappearing in Nigeria as a result deforestation are *Irvingia gabonensis*, *Treculia Africana*, *Parkia biglobosa*, *Vitex doniana*, *Shynocentrum jollyanum*, *Synsepalum dulcifum*, *Thaumatococcus danielli* and *Piper umbellatum* (Hyman, 1993). Furthermore, the underdeveloped sprouted cuttings died back because of its inability to root properly leading to the denial of supply of nutrient from the soil to support physiological activities of the sprouted cuttings. As important as *Piper umbellatum* is, and other indigenous plant species, they have suffered unwarranted neglect in research development and utilization. Yet as traditional sources of fruit, meats, spices condiments, leafy veggies, edible oil and beverages, these naturally occurring plant species play significant roles in ameliorating the food problems and health care of the tropics and contribute immensely to the socioeconomic welfare of the rural people (Okafor, 1999).

Other problems are appropriate propagation technique, the rapid disappearance of genetic reservoir of plants within and outside constituted forest reserves. With the destruction of natural forests, there is concern of what can be done to avoid extinction of existing species. Since the in-situ conservation of the natural forest species is no longer adequate, there is need for ex-situ conservation of *Piper umbellatum*. The study would also supply information, which is lacking or has not been supplied.

The species has been shown to be of dietary and medicinal importance and the ability to propagate *Piper umbellatum* could facilitate its use in veggies garden. In order to ensure continuous existence of *Piper umbellatum* and save it from imminent extinction, this study was conducted to have a good understanding of *Piper umbellatum* propagation, seedlings survival and growth improvement. Therefore this study specifically aims to evaluate the effect of three hormones with two different concentrations on the rooting of *Piper umbellatum*, determine which part of the plant will root easily as well as the plant hormone best for plant growth.

MATERIALS AND METHODS

The experiment was carried out at the Forestry Research Institute of Nigeria (FRIN) fruit nursery, Ibadan, Nigeria. Ibadan lies in the southern limit of tropical semi deciduous rainforest with a forest savanna. Located on latitude 7°26' N and longitude 3°54'E with an elevation of 750m above sea level (Oguntoyinbo, 1987), it has two seasons (dry and rainy season), mean total rainfall of 1470.06mm falling in 109days, mean minimum and maximum temperature of 21.42°C and 26.46°C respectively.

Preparation, Treatment and Data Collection

Piper umbellatum was found in Oni-gambari Forest Reserve, Oyo State and samples were brought to Forest Herbarium, Ibadan (FHI) for identification. Top soil (sandy-loam) was collected from FRIN, sieved with 5mm aperture iron sieve, sterilized in sterilization chamber at 121°C for 1hour 30minutes and allowed to stay for 2 days before use. The uniformly selected shoots of wildlings were cut and the cut ends were allowed to remain under water to minimize transpiration and water loss from the shoot. A clean slant cut of the node was made with a sharp knife. Three types of cuttings used were apical, sub terminal and basal node cuttings. The number of stem nodes on wildlings with uniform girth was used to obtain uniform size of cuttings. Three commercial growth regulators were used namely: Indole-3-butyric acid (IBA), Gibberellic acid (GA) and Naphthalene Acetic acid (NAA). Each of the growth regulators had 2 levels of concentrations as follows: 50 parts per million (50ppm) and 100 parts per million (100ppm). For each of the growth regulators, 50ppm was prepared by weighing out 5mg and dissolving it in 100ml of ethanol while 100ppm was prepared by weighing out 10mg and dissolving it in 100ml of ethanol. The poly bags of diameter of 20cm and height of 40cm were filled with top soil. After proper selection of the cuttings and preparation of hormones concentrations, the base of the cuttings were dipped into the concentration for few seconds and planted immediately after treatment. Distilled water served as the control. Alcohol was applied to the hormones for the reasons: to increase the half-life of the hormones, reduce the bio-degradability of the hormones and to dissolve the hormones completely to form a clear saturated solution.

The following agronomic and silvicultural parameters were measured. Survival percentage was derived as:

Survival Percentage = $^{X}/_{Y} * 100$

Where: X = Number of cuttings that sprouted; Y = Number of cuttings planted.

Plant height was measured with the aid of meter rule. Stem diameter was measured with vernier caliper. Visual count was carried out on individual seedlings. The length of each leaf stalk was measured from the base to the axil of the leaf and node. Leaf area was also measured. Parameters were measured on weekly basis.

Experimental Design

The design of the experiment was factorial in a completely randomized design. Three factors considered in the experiment are growth regulators, concentrations (ppm) and cutting types. Growth regulators had four types, concentration had two levels and cutting types had three levels. Thus, the 4x2x3 factorial experiment gave 24 treatment conditions. The seedlings were watered constantly to avoid drying out. Also, excessive watering that could lead to leaching out of nutrients and conditions for damping-off disease was avoided. *Piper umbellatum* was raised under palm frond shed, creating a canopy such as existed in the natural habitat where it was found.

Data Analysis

ANOVA was used for data analysis and the significant treatments were further determined using least square difference (LSD) were appropriate.

RESULTS AND DISCUSSION

The result obtained from the experiment at the end of sixteen weeks shows the effects of three hormonal treatments at two different levels on cuttings of *Piper umbellatum*.



Plate 1: *Piper umbellatum* in the wild and seedlings raised using different nodal cuttings and Hormones

Table 1: Effects of treatment on Mean Plant Height, Stem Girth, Leaf Count and Leaf Area at 21 weeks after planting

Hormones	Nodal Position	Plant Height (cm)	Stem Girth	Leaf Count	Leaf Area (cm^2)
	Basal	4.6^{a}	1.6^{a}	6.7^{a}	247.9^{a}
NAA	Terminal	3.9	1.4^{a}	5.4^{a}	171.6^{b}
	Sub-terminal	3.5	1.2^{b}	2.6^{b}	100.3^{c}
	Basal	3.9	1.5^{a}	6.4^{a}	206.7^{a}
IBA	Terminal	3.6	1.3^{b}	5.2^{a}	140.2^{ab}
	Sub-terminal	3.5^{b}	1.1^{c}	2.5^{b}	84.1^{b}
	Basal	3.9^{a}	1.5	6.1^{a}	206.7^{a}
GA	Terminal	3.5^{b}	1.3	4.0^{b}	140.2^{ab}
	Sub-terminal	3.1^{c}	1.1	2.3^{c}	84.1^{b}
	Basal	3.6^{a}	1.4^{a}	5.2^{a}	181.2^{a}
Control	Terminal	3.2^{b}	1.2^{b}	3.8^{a}	109.8^{b}
	Sub-terminal	3.1^{b}	1.1^{c}	2.0^{b}	76.0^{b}

Values followed by different alphabet are significantly different at 5% level

Table 1 showed that the basal node cuttings for all the treatments had the highest plant growth characteristics followed by the terminal and sub-terminal node cuttings. Plant growth characteristics across the treatments were significantly higher in plant hormone treatments ($p < 0.05$) than in untreated plants. Plant growth characteristics from NAA treatment were significantly higher compared with that of the other treatments. Basal node cutting of NAA had the highest mean plant height (4.6cm) followed by IBA and GA (3.9cm each) while Control had the least (3.6cm). Basal node cutting of NAA had the highest mean stem girth (1.6cm) followed by IBA and GA (1.5cm each) while Control had the least (1.4cm). Basal node cutting of NAA had the highest mean leaf count (6.7) followed by IBA (6.4), GA (6.1 each) while Control had the least (5.2). Basal node cutting of NAA had the highest mean leaf area (247.9cm^2) followed by IBA and GA (206.7cm^2 each) while Control had the least (181.2 cm^2). Therefore, the basal node cutting of NAA treatment performed best in terms of plant growth characteristics.

Table 2: *Piper umbellatum* Sprouting Percentage at 50ppm and 100ppm Levels of Treatment

Nodal Position	GA		NAA		IBA		Total
	50ppm	100ppm	50ppm	100ppm	50ppm	100ppm	
Terminal	0	0	3	3	0	5	11
Sub-terminal	2	2	4	3	2	4	17
Basal	1	4	5	5	5	4	24
Total	3	6	12	77	7	13	52
Percentage	6%	11%	23%	21%	14%	25%	100%

Table 3: *Piper umbellatum* Sprouting Percentage of different Treatments

Nodal Position	GA	NAA	IBA	Control	Total	Percentage
Terminal	0	6	5	1	12	19%
Sub-terminal	4	7	6	5	22	35%
Basal	5	10	9	5	29	46%
Total	9	23	20	11	63	
Percentage	14%	37%	32%	17%	100%	100%

In Table 3, it was found that the basal node cuttings had the highest number of raised seedlings which was 46%. In general (Table 2), the basal cuttings performance in response to hormonal treatments showed that IBA at 50ppm and 100ppm had 5 and 4 seedlings respectively, NAA at 50ppm and 100ppm had 5 seedlings each, GA at 50 ppm and 100ppm had 1 and 4 seedlings respectively. Table 3 revealed that GA had 5, NAA had 10, IBA had 9 and Control had 5 in total. The sub-terminal node recorded 35%. In response to hormonal treatment, GA had 4, NAA had 7, IBA had 6 and Control had 5. The lowest was the terminal node with 19% sprouts. Table 3 revealed that terminal cuttings treated with GA at these two levels of concentrations did not sprout, but those treated with NAA had 6, IBA had 5 and Control had 1. Summarily, NAA had the highest sprouting percentage (37%) followed by IBA (32%), Control (17%) and GA (14%). Lack of adequate understanding of propagation of *Piper umbellatum* leads to poor and inadequate raising of seedlings even with the application of hormones. Good quality cuttings is however critical to raising or the production of plant material in agriculture. Presently, *Piper umbellatum* exists in the wild. There are several attempts using various methods to vegetatively propagate cuttings of *Piper umbellatum*. These however failed. Cuttings of various nodal positions were set under propagator using river sand and topsoil as rooting media (Plate 4 and 5 respectively). These failed to develop because propagator maintains constant humidity and temperature which does not exist in the nature where *Piper umbellatum* is found.

CONCLUSION AND RECOMMENDATIONS

The best hormonal treatment that has the greatest effect on the vegetative propagation of *Piper umbellatum* was Naphthalene Acetic acid (NAA). Also, NAA had the highest sprouting percentage. Considering the different levels of hormones (50ppm and 100ppm) that were used in this study, it was concluded that Naphthalene Acetic acid at 100ppm treatment of the basal node performed best because it gave the highest performance of plant growth characteristics. It was concluded that the treatment of terminal node had the lowest sprouting and sub-terminal node was the poorest in plant growth performance. Gibberellic acid was concluded to be the poorest because it performed poorly. The poorest level of hormones application was at level 1 (i.e. 50ppm). This experiment indicates that the nodal position for obtaining the best performance of *Piper umbellatum* cuttings is the basal node. Naphthalene Acetic acid performed best, followed by Indole-3-butyric acid and Gibberellic acid while control that was without the application of plant hormones was the least in terms of plant growth. Thus, in considering hormonal treatment to hasten the growth of *Piper umbellatum*, Naphthalene Acetic acid should be used to obtain the best seedling product

Based on the result of this study, the following recommendations are made:

Piper umbellatum is one of the rich parts of tropical forest biodiversity that is harvested locally as veggies, also a medicinal plant that needs to be researched upon and possibly make available at all seasons of the year to improve the economy of the rural populace. In the propagation of *Piper umbellatum*, setting of cuttings either in sterilized sand or top soil in a propagator may not be required because of the failure of the cuttings to develop. It is possible to domesticate *Piper umbellatum* using shades of palm frond without high level of technicalities. *Piper umbellatum* may be raised under natural conditions of shade, temperature, humidity and light. The performance of raising the seedlings can be enhanced using hormones such as Naphthalene Acetic acid (NAA) at 100ppm. This can be applied to the basal node. In the absence of hormones especially with the local veggie growers in rural areas, the basal part of healthy stock of *Piper umbellatum* without hormonal treatment can be used. Government policies and extension services should be designed with efforts aimed at intensifying the domestication of the species by planting appropriately, putting into consideration the aforementioned recommendations. This includes establishing natural resources, technical assistance, credit, market opportunities, sustainable extractive reserve and silvicultural management accounted for within national economic planning and recognizing the long-term benefit of non-timber forest product such as those of *Piper umbellatum*.

REFERENCES

CIDA. (1992): Forest Issues, Non-wood Products Forestry Conservation Sector Natural Resources Division, Hall, Quebec, Canada.

F.A.O. (1986): Some Medicinal Plant of Africa and Latin America. F.A.O. Forestry Paper 67, Rome, pp. 241-245.

Hutching, M.J. (1986): The Structure of Plant Population in Plant Ecology. M. Crawley (Ed.) Blackwell Scientific Publication, London, pp. 97-136.

Hyman, L.E. (1993): Forestry Policies and programmes for Fuelwood Supply in Northern Nigeria. *Journal of Land Use Policy*, Vol. 10, pp. 26-43.

Oguntoyinbo, E.Y. (1987): Information and Content Analysis of Hydrometeorological Networks: A case study of the Ogun-Oshun River Basin in Nigeria. Unpublished M.Sc. Thesis, Department of Geography, University of Ibadan.

Okafor, J.C. (1980): Edible indigenous woody plants in the rural economy of the Nigerian Forest Zone. *Forest Ecology and Management*, Vol. 3, pp. 15-24.

Okafor, J.C. (1999): The use of farmer knowledge in non-wood forest product research. In: Sunderland, T.C.H., Clark, L.E. and Vantome, P. (eds.): Current research issues and prospects for conservation and development: non-wood forest products of Central Africa, FAO, Rome. pp. 123-132.

Osameobo, J. G. (1993): Agricultural Land use in Nigeria Forestry Reserve: Towards a Solution to Problems or Conflict in Biotic Conservation. *Journal of Land Use Policy*, Vol. 1, No. 4, p. 101.

Nwoboshi, C.L.N. (1982): Principles of Tropical Silvicuture, Ibadan Press, University of Ibadan, Nigeria.

Salomon, E. (1988): Effect of Paclobutrazol and Gibberellic acid (GA_3) on the Root and Biomass Partitioning of Citrus Leaf Cutting. *Plant Growth Regulator Abstracts*, Vol. 15, No. 8, p. 232.

Thimann, K. V. and Koepli, J. B. (1935): Identity of Growth promoting and Root forming Substances of Plants. *Nature*, Vol. 135, pp. 101-102.

Thimann, K.V. (1936): Auxin and the Growth of Roots. *Annual Journal of Botany*, Vol. 23, pp. 561-569.

Public Perception, Awareness and Willigness to Visit Federal University of Agriculture, Abeokuta Zoological Park

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ABSTRACT

The public perception, awareness and willingness to visit Federal University of Agriculture, Abeokuta Zoological Park (FUNAAB) was investigated with the view to providing information salient information on Zoological Park. Data were collected through the use of structured and pretested questionnaire administered interpersonally to the respondents. The questionnaires were 200 in which 100 copies of the questionnaire were administered in neighboring and another 100 copies of the questionnaires were administered in non-neighboring communities. The data were analyzed using descriptive and inferential statistical tools. Some of the descriptive statistical tools include frequency, mean, median and mode, pearson correlation and spearman's rho, inferential statistical tools were also employed to find out the level of public perception, awareness and willingness to visit FUNAAB Zoo park and some of their selected socio-economic variables. The results reveals that the modal age group of the sampled respondents in Odeda Local Government falls within the age range of 16-19 years while only few were within the age range of 27-30. The results of the study further shows that they were 101 females (50.0%) and 99 males (49.5%). This was an indication that women were more involved in recreation than men. Unmarried respondents where (93.5%), with 6% married and only 0.5% divorced, while 98% of them were educated up to tertiary school level followed by those in secondary education which accounted for about 5% of the total while those that were in primary education were about 2%. The respondents that were involved in visiting the zoo park were Christians (83.5%) with (16.5%) for Islamic religion, in which Yoruba ethnic group were in the (92%) with Igbo having (4.5%) and Hausa having (3.5%). The analysis of the 5-point likert scale revealed that 10% of the respondents were unfavorably willing to visit FUNAAB Zoo Park, while 90% were favorably. The analysis of the awareness level also revealed that 16.5% of the respondents were unfavorably aware of FUNAAB Zoo Park, while 83.5% were favorably aware. Their ethnicity (R=0.159) was found to have a negative correlation, but statistically significant relationship with their willingness to visit FUNAAB zoo park at 0.05 probability level showing that their ethnicity will influence their willingness to visit the FUNAAB zoo park. Also their gender (R=1.000) was found to have a positive and statistical significant relationship with their willingness to visit the zoo park at 0.05 probability level which implies that their gender may inversely influence their level of willingness. It was recommended that the management should improve on its publicity and enlightenment so as to make FUNAAB Zoo Park more popular.

Keywords: Awareness, willingness, zoological park, publicity

INTRODUCTION

Recreation is the employment of time for the refreshment of one's body or mind. It is a form of relaxation; play or amusement, something that pleasantly occupies one's time after work is done. Examples of recreation include visiting parks, zoos, sea sides, sports ground, forest sightseeing, canoeing, camping, hiking, walking and mountain climbing (Okojie and Amujo, 2011). The benefit of recreation cannot be overemphasized. It includes boosting tourism, revitalizing cities, attracting investments and enhancing good health among others (Okojie and Amujo, 2011). Bergstrom and Cordell (2004) assert that recreation impacts on agriculture and economic development in many rural areas. Nigeria being a labor based agrarian country needs a lot of recreation. Recreation and tourism go hand in hand. In Nigeria, there are so many tourist areas which people visit for Recreation and tourism. Tourism is travel for recreation, leisure, religions, family or business purposes, usually for a limited duration (The Free Encyclopedia-TFE, 2015). The World Tourism Organization defines tourism as people travelling to and staying in a place outside their usual environment for not more than one consecutive year for leisure, business and other purposes (TFE, 2015).

Tourism is an important opportunity to diversify local economies (Ayodele and Falade, 2003). It can develop in poor and marginal areas with few other opportunities and diversification options. It can bring about non-material benefits such as pride to local culture and adds value to the surrounding natural environment in the eyes of local communities (Ijeomah, 2007).

A zoological garden is a collection of wild animals in captivity and may include zoological gardens, biological parks, safari parks, public aquariums, bird parks, reptile parks, insectariums, and other collections of wildlife primarily for public exhibition,

education, scientific and conservation purposes' (SEAZA, 2002). The world association of zoos and aquariums states that a zoo is a 'venue for researchers and visitors to meet, thus assisting with the public understanding of science and offering opportunities to raise awareness about research and its conservation implications and has a 'powerful part in achieving global sustainability and should inspire people who visit zoos to become part of the same movement (WAZA, 2005). As a tourist destination, zoos are the primary institutional location of wild animal presentation' and are very much part of the 'tourist trail' (Beardsworth and Bryman, 2001). Zoos as a tourist attraction are controversial because of the perceived conflicting roles of zoos (Harrison, 2004; Mazur, 2001).

Zoological gardens have evolved from mere entertaining menageries to scientifically and professionally managed zoological institutions (Hutchins & Conway, 1995; Mazur, 2001; Rabb, 1996). With growing environmental consciousness that began in the 1960s, the caging and maltreatment of captive animals have been criticized especially by environmentalists and animal welfare groups. In the last two decades, zoos, particularly those in western countries (e.g.UK, USA), have re-evaluated their roles and practices, and several are now operating as conservation or environmental centers (Rabb, 1996). Kelly (1997) supported the view that zoos should be more than a collection of animals; it should be a tool to conserve wildlife and their natural habitats. however, numerous zoos particularly those in developing countries still operate under substandard condition and animal care practices (Almazan *et al.*,2005; Bagarinao, 1998; Mallapur *et al.*,2005), and many are managed mainly to benefit human's need for amusement and entertainment. There are about 10,000–12,000 zoos and animal parks in the world (WAZA,2005), of which about 650–1000 are recognized internationally for their good practice in animal management and species conservation (Armstrong *et al.*, 1993; Kelly, 1997; Van Linge, 1992). Zoos are urged by the global conservation community to enhance their conservation commitment in relation to their recreational and educational roles (WAZA, 2005).

Perception plays very important role in making some issues important and some unimportant, this is due to many reasons; sometimes perceptions are affected by lots of other things. According to Severin (2001), different psychological factors influence perceptions and they include past experience, cultural expectations, motivations, moods, needs and attitudes. According to Feldman (1999), "Perception is the sorting out, interpretation, analysis and integration of stimuli involving our sense organs and brain". Public perception is not necessarily inaccurate or based on something other than the truth. The public at large can often receive enough factual information in order to form a general opinion about a public figure, celebrity or industry without relying on innuendo or unfounded rumors. There can be instances, however, when the perception of a situation is affected by other issues, such as cultural bias or prejudice (Michael, 2015). This underscores the objective of the study which are:

-To describe the socio-demographic characteristics of the respondents.
-To determine the perception of the people on awareness of FUNAAB Zoo Park.
-To determine the willingness of public to visit FUNAAB zoo park.

METHODOLOGY

Study Area

The study was carried out at Federal University of Agriculture Abeokuta ZOO PARK Ogun State. The site is located within the tropical rain forest zone at latitude 7°55'N and longitude 3°2'E and 2°37' of the equator.



Fig.1: Map of FUNAAB Zoo Park

SAMPLING PROCEDURE

Communities in FUNAAB environs at Odeda Local Government were stratified randomly sampled. A total of 200 copies of the questionnaires were administered to the strata. 100 copies of the questionnaires were administered to the people living in each stratum (neighboring and non-neighboring community). The neighboring communities are Isolu and FUNAAB campus gate while the non-neighboring communities are Camp, Osiele, Obantoko and Aregbe, Abeokuta Ogun state.

Data Collection

The study is to focus on public perception, awareness and willingness to visit FUNAAB Zoo Park. The data was collected through primary and secondary source. Primary source involve the use of a well-structured questionnaire and the secondary source involves the use of literatures and journals. Pre-tested and structured questionnaire were administered interpersonally to people living in the selected communities in Odeda Local Government, Ogun State. The questionnaire was sectioned into 3 parts. Section 'A' obtained socio-economic information of the respondents. Section 'B' addressed the Public Perception, Awareness and the respondent's Willingness to visit FUNAAB Zoo Park. While Section 'C' addressed the public perception of the zoo park. A five point likert scale rating ; Strongly agree (5), Agree (4), Undecided (3), Disagree (2), and Strongly disagree (1) for positive and vice versa for negative was used to classify respondent's willingness to visit FUNAAB zoo park.

Data Analysis

Data collected from the study were analyzed using descriptive statistical tools such as mean, median, percentage and frequency counts was used to summarize the data collected. The Pearson correlation and spearman's rho to establish the relationship and association respectively between the respondents' public perception, awareness and willingness to visit FUNAAB Zoo park and some of their selected socio-economic characteristics. The models are specified below;
For spearman's rho:

$$\rho = 1 - \frac{6\sum d_i^2}{n(n^2-1)}$$

Where,

n = number of paired ranks
d = difference between the paired ranks

RESULTS AND DISCUSSION SOCIO-ECONOMIC CHARACTERISTICS

This section reveals the personal [social] characteristics such as age, sex, marital status, educational level, social group and the economic characteristics of the respondents involved. Some of the socio-economic characteristics of respondents in Odeda Local Government i.e. the study area are summarized below.

Table 1: Demographic Characteristics of respondents

Characteristics	Frequency	Percentage
Sex		
Male	99	49.5
Female	101	50.5
Total	200	100
Age		
16-20	124	62.0
21-25	50	25.0
26-30	17	8.5
>31	9	4.5
Total	200	100
Marital Status		
Singled	188	6.0
Married	12	94.0
Total	200	100
Religion		
Christianity	167	83.5
Islam	33	16.5
Total	200	100

Tribe		
Hausa	2	1.0
Igbo	7	3.5
Yoruba	184	92.0
Others	7	3.5
Total	200	100
Educational Background		
None	2	1.0
Primary School	4	2.0
Secondary School	10	5.0
Tertiary School	184	92.0
Total	200	100
Occupation		
Student	118	59.0
Civil Servant	4	2.0
Entrepreneurship	78	39.0
Total	200	100

Table 2: Respondent's Awareness, Knowledge and Willingness to Visit FUNAAB Zoo Park

Knowledge	**Frequency**	**Percentage**
Awareness		
Yes	167	83.5
No	33	16.5
Total	200	100
Length of Awareness		
1-2 years	132	66.0
3-4 years	45	22.5
5-6 years	8	4.0
>6 years	15	7.5
Total	200	100
Source of Information		
Parent	5	2.5
Mass media	5	2.5
Student	34	17.0
Friend	95	47.0
Personal Observation	61	30.0
Total	200	100
Willingness to visit		
Yes	180	90.0
No	20	10.0
Total	200	100
Frequency of visit		
Weekly	56	28.0
Monthly	49	24.5
Yearly	59	29.5
Others	36	18.0
Total	200	100
Pay towards maintenance		
Yes	124	62.0
No	76	38.0
Total	200	100
Amount Willing to pay (₦)		
100	147	73.5
200	22	11.0
300	6	3.0
400	5	2.5
500	13	6.5
1000	7	3.5
Total	200	100

Respondent's Awareness of FUNAAB Zoo Park

It was revealed in the study that 167(83.5%) of the respondent are aware of FUNAAB Zoo Park while 33(16.5%) of the respondent indicated their unawareness of the Zoo Park. It was further revealed in the study that about 132(66%) of the respondent who had the knowledge of the park had it within the average of two years and mostly through friends, they also had the knowledge of the zoo park through fellow student 34(17%) and through personal observation 61(30.5%).

Respondents' knowledge and willingness to visit FUNAAB Zoo Park

One hundred and thirty (65.0%) of the respondents' that indicated awareness had the knowledge of the FUNAAB Zoo Park. Concerning the willingness to visit the Zoo Park, 180(90%) admit they are willing to visit the Zoo Park while only 20 (10%) says otherwise. Amongst those that chose to visit the park, 59 (29.5%) of the respondents' are willing to visit the park yearly, 56 (28%) are willing to visit within a week, while 49 (24.5%) are willing to do so in a month.

PEARSON CORRELATION BETWEEN THE RESPONDENTS WILLINGNESS TO VISIT FUNAAB ZOO PARK AND SOME SELECTED SOCIO ECONOMIC VARIABLES

In order to determine the relationship between the respondents willingness to visit FUNAAB Zoo Park, Pearson correlation was used. The results of the Pearson correlation revealed that respondent's awareness level was found to be negatively correlated and statistically non-significant in relation to their age (R= -0.134) at 0.05 probability level which implies that increase in their age class will influence their willingness to visit FUNAAB Zoo Park. Their level of education was found to have a positive and a statistical significant relationship with their awareness at 0.01 probability levels, which implies that as the respondent's level of education Increases, the more favorably they will be willing to visit FUNAAB Zoo Park in the study area. Also their willingness to contribute funds for the management was found to have a positive and a statistical significant relationship with their awareness of FUNAAB Zoo Park at 0.05 probability level.(Table, 3).

PEARSON CORRELATION BETWEEN THE RESPONDENTS AWARENESS OF FUNAAB ZOO PARK AND SOME SELECTED SOCIO ECONOMIC VARIABLES

In order to determine the relationship between the respondents awareness of FUNAAB Zoo Park, Pearson correlation was used. The results of the Pearson correlation revealed that respondent's awareness level was found to be negatively correlated and statistically non-significant in relation to their age (R= -0.134) at 0.05 probability level which implies that increase in their age class will influence their of awareness of FUNAAB Zoo Park. Their level of education was found to have a positive and a statistical significant relationship with their awareness at 0.01 probability level, which implies that as the respondent's level of education Increases, the more favorably they will be aware of FUNAAB Zoo Park in the study area. Also, their willingness to contribute funds for the management was found to have a positive and a statistical significant relationship with their awareness of FUNAAB Zoo Park at 0.05 probability level.

Table 3: **Pearson correlation between the respondents' willingness to visit FUNAAB Zoo Park and some selected socio economic variables.**

Correlations

		age(year)	educational background	are you willing to visit FUNNAB zoo park	if yes to (16), how much are you ready to contribute for the management fund
age(year)	Pearson Correlation	1	-.134*	.117*	.399**
	Sig. (1-tailed)		.029	.050	.000
	N	200	200	200	200
educational background	Pearson Correlation	-.134*	1	.088	.042
	Sig. (1-tailed)	.029		.107	.279
	N	200	200	200	200
are you willing to visit FUNNAB zoo park	Pearson Correlation	.117*	.088	1	.476**
	Sig. (1-tailed)	.050	.107		.000
	N	200	200	200	200
if yes to (16), how much are you ready to contribute for the management fund	Pearson Correlation	.399**	.042	.476**	1
	Sig. (1-tailed)	.000	.279	.000	
	N	200	200	200	200

*. Correlation is significant at the 0.05 level (1-tailed).
**. Correlation is significant at the 0.01 level (1-tailed).
R= correlation coefficient

TABLE 4: Pearson correlation between the respondents' awareness of FUNAAB Zoo Park and some selected socio economic variables.

Correlations

		age(year)	educational background	are you aware of FUNAAB zoo park	knowledge about FUNAAB zoo park
age(year)	Pearson Correlation	1	-.134*	.076	.452**
	Sig. (1-tailed)		.029	.143	.000
	N	200	200	200	200
educational background	Pearson Correlation	-.134*	1	.031	.055
	Sig. (1-tailed)	.029		.332	.218
	N	200	200	200	200
are you aware of FUNAAB zoo park	Pearson Correlation	.076	.031	1	.270**
	Sig. (1-tailed)	.143	.332		.000
	N	200	200	200	200
knowledge about FUNAAB zoo park	Pearson Correlation	.452**	.055	.270**	1
	Sig. (1-tailed)	.000	.218	.000	
	N	200	200	200	200

*. Correlation is significant at the 0.05 level (1-tailed).
**. Correlation is significant at the 0.01 level (1-tailed).

Spearman's Rho Analysis Showing the Correlation between the Respondents' Willingness to Visit FUNAAB Zoo Park and some Selected Socio-economic Variables

The results of the spearman's rho analysis are summarized in (table 5). The table revealed the respondents willingness level was found to be positively correlated and statistically significant in relationship with their marital status (R= 1.000) and religion (R=0.042) at 0.05 probability level which implies that as the respondents are conversant with the important, the more favorably they will be willing to visit the FUNAAB zoo park in the study area. Their ethnicity (R=0.159) was found to have a negative correlation, but statistically significant relationship with their willingness to visit the FUNAAB zoo park at 0.05 probability level showing that their ethnicity will influence their willingness to visit FUNAAB zoo park. Also their gender (R=1.000) was found to have a positive and statistical significant relationship with their willingness to visit the zoo park at 0.05 probability level which implies that their gender may inversely influence their level of willingness. (Table 5).

Table 5: **Spearman's rho analysis showing the correlation between the respondents' willingness to visit FUNAAB Zoo Park and some selected socio-economic variable**s

Correlations

			Gender	marital status	ethnic group	Religion
Spearman's rho	Gender	Correlation Coefficient	1.000	.024	.076	.171*
		Sig. (2-tailed)	.	.741	.283	.016
		N	200	200	200	200
	marital status	Correlation Coefficient	.024	1.000	.166*	.096
		Sig. (2-tailed)	.741	.	.019	.176
		N	200	200	200	200
	ethnic group	Correlation Coefficient	.076	.166*	1.000	.033
		Sig. (2-tailed)	.283	.019	.	.645
		N	200	200	200	200
	Religion	Correlation Coefficient	.171*	.096	.033	1.000
		Sig. (2-tailed)	.016	.176	.645	.
		N	200	200	200	200

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

The analysis shows that majority of the respondents are in the range of 16-19 years while only few were within the age range of 27-30. This implies that a large percent of the respondents were in the productive age which can enjoy recreation and parks. The result revealed in the study that 167 (83.5%) of the respondents are aware of FUNAAB Zoo Park while 33 (16.5%) of the respondents indicated their unawareness of the Zoo Park. It was further revealed in the study that about 132 (66%) of the respondents who had the knowledge of the park had it within the average of two years and mostly through friends, they also had the knowledge of the zoo park through fellow student 34 (17%) and through personal observations 61 (30.5%). The suggestions made by the respondents on to make FUNAAB zoo park acceptable to them of which multiple suggestions were given, making all suggestions around up to the affordable price, varieties of wild animals, provision of tour guard during visitation and to create more awareness by using of big board at camp junction. The respondents perception level about FUNAAB zoo park shows a large percentage of 130(65.0%), while 70(35.0%) don't have knowledge about FUNAAB Zoo Park. The respondents awareness level of FUNAAB zoo park shows that a large percentage of the respondents 167(83.5%) are aware of FUNAAB zoo park, while 33(16.5%) of the respondents are unaware of FUNAAB Zoo Park. The respondents willingness level to visit FUNAAB zoo park shows that a large percentage 180 (90%) of the respondents are indifferent about their willingness to visit FUNAAB zoo park, while 20 (10%) are not aware of the zoo park. In order to determine the relationship between the respondents awareness of FUNAAB Zoo Park, Pearson correlation was used. The results of the Pearson correlation revealed that respondent's awareness level was found to be negatively correlated and statistically non-significant in relation to their age (R= -0.134) at 0.05 probability level which implies that increase in their age class will influence their of awareness of FUNAAB Zoo Park. Their level of education was found to have a positive and a statistical significant relationship with their awareness at 0.01 probability level, which implies that as the respondent's level of education Increases, the more favorably they will be aware of FUNAAB Zoo Park in the study area. Also, their willingness to contribute funds for the management was found to have a positive and a statistical significant relationship with their awareness of FUNAAB Zoo Park at 0.05 probability level. The results of the spearman's rho analysis are summarized the respondents willingness level was found to be positively correlated and statistically significant in relationship with their marital status (R= 1.000) and religion(R=0.042) at 0.05 probability level which

implies that as the respondents are conversant with the important, the more favorably they will be willing to visit the FUNAAB zoo park in the study area. Their ethnicity (R=0.159) was found to have a negative correlation, but statistically significant relationship with their willingness to visit the FUNAAB zoo park at 0.05 probability level showing that their ethnicity will influence their willingness to visit FUNAAB zoo park. Also their gender (R=1.000) was found to have a positive and statistical significant relationship with their willingness to visit the zoo park at 0.05 probability level which implies that their gender may inversely influence their level of willingness.

CONCLUSION

Only few people claimed not to be aware of FUNAAB Zoo Park and a lot of the respondents are willing to visit the Zoo Park if the price is affordable and if there are varieties of wild animals. It can be concluded from this study that despite the large number of respondents' perception about FUNAAB Zoo Park, a larger percentage are still in indifferent about the zoo park, while minority which has the low percentage have an unfavorable perception about the FUNAAB zoo park . The management implication is that there is not enough awareness and enlightenment about FUNAAB Zoo Park which was responsible for indifferent and unfavorable perception about FUNAAB Zoo Park. In the light of the above, there is need to step up a wide extension service on this new innovation so as to make it attractive and popular.

RECOMMEDATIONS

In spite of the advantages of FUNAAB Zoo Park, which can serve as revenue generation, also create employment opportunities for the unemployed, education, research and improvement of the environment. Information on the respondent's perception, awareness and willingness to visit FUNAAB Zoo Park is not scarce in the study areas. However, the management must not relent on publicity and enlightment so as to make FUNAAB Zoo Park more popular.

REFERENCES

Almazan, R .R., Rubio, R .P. and Agoramoorthy, G. (2005) Welfare evaluations of nonhuman animals in selected zoos in the Philippines. *Journal of Animal Welfare Science* 8 (1), 59–68.

Armstrong, J., Gibson, N ., Howe, F. and Porter, B. (1993) The role of *ex situ* conservation. In C . Moritzand and J. Kikkawa (eds) *Conservation Biology in Australia and Oceania* (pp. 353–357). Norton: Surrey Beatty & Sons.

Ayodele, A. I. and Falade G. O. 1993. Some aspects of the Tourism Potential of Nigeria National Parks, Environment and Tourism in Nigeria. Choker B.O. Eds. pp. 211-218.

Bagarinao, T. (1998) Nature parks, museums, gardens, and zoos for biodiversity conservation and environmental education: The Philippines. *Ambio* 27 (3), 230–237.

Beardsworth, A . and Bryman, A . (2001) The wild animal in late modernity. *Tourist Studies* 1 (1), 83–104.

Bergstrom J.C, Cordell H.K (2004). A comment on the rural economic development of outdoor recreation in Georgia, American J. Agric. Resource Econ., 42: 249-261.

Feldman, J. (1999). The role of objects in perceptual grouping. *Acta Psychologica*. 102. 137-163.

Harrison, B. (2004) Natural order. *Attractions Management* 9 (2), 46–48.

Hutchins, M . and C onway, W. (1995) Beyond N oah's ark: The evolving role of modern zoological parks and aquariums in field conservation. *International Zoo Yearbook* 34,117–130.

Ijeomah, H.M. 2007. Impact of Tourism on Perceived Poverty Alleviation in Plateau State, Nigeria. PhD Thesis. Department of Wildlife and Fisheries Management, University of Ibadan, Oyo State, Nigeria. 301pp.

Kelly, J.D. (1997) E ffective conservation in the twenty-first century: The need to be more than a zoo. An organisation's approach. *International Zoo Yearbook* 35, 1–14.

Mallapur, A .,Waran, N . and S inha, A . (2005b) Factors influencing the behaviour and welfare of captive lion-tailed macaques in Indian zoos. *Applied Animal Behavior Science* 91 (3/4), 337–353.

Mazur, N .A. (2001) *After the Ark? Environmental Policy Making and the Zoo*. M elbourne: Melbourne University Press.

Michael, P. (2015). *What is public perception?.* Retrieved September 25, 2015 from http:// www.wisegeek.com/what-is-perception.html

Okojie, L.O and Amujo, B.T. (2011). Socio-economic determinants of on-day site demand for recreation in old Oyo National Park, Nigeria *Journal of Development and Agricultural Economics* Vol. 3(6), pp. 230-235.

Rabb, G.B. (1996) The changing roles of zoological parks in conserving biological diversity. *Biological Conservation* 76, 210.

SEAZA (2002) South East Asian Zoos Association Constitution, Article 1 at http:/_/www_.seaza.org/AboutPolicies.html. Accessed 28/7/04. Severin, J.W. and Tankard, Jr. W.J. (2001). *Communication theories: origins, methods and uses in mass media*, 5th edition, Longman.

The Free Encyclopedia-TFE (2015): Tourism. Retrieved September 21, 2015, from en.m.wikipedia.org/wiki/Tourism

Van Linge, J.H. (1992) How to out-zoo the zoo. *Tourism Management*, March 115–117. WAZA (2005) *Building a Future for Wildlife – The World Zoo and Aquarium Strategy.* Bern, Switzerland: World Association of Zoos and Aquariums.

Assessment of Genetic Variation in *Chrysophyllum albidum* G. Don using Cp SSR Marker

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ABSTRACT

Chrysophyllum albidum G. Don, commonly known as "African Star Apple", is a native to many parts of tropical Africa, widely distributed in West, Central, and East Africa for its edible fruits and various ethno-medical uses. In Nigeria, C. albidum is classified among the endangered tree species with a high probability of going into extinction in the near future. The species is endowed with a high degree of climatic adaptability. C. albidum does not only exist in rainforest, it also thrives well in the savanna where there is less rainfall and high temperature. The wide geographical and climatic distribution is an indicative of the fact that there exists a tremendous genetic variation, which needs to be identified for immediate conservation. Juvenile leaves of C. albidum were collected from fifteen accessions of C. albidum across two ecological zones of Osun State. The leaves were cleaned and preserved with silica gel in sealed nylon. Total genomic DNA was extracted from 0.020 g powder of silica gel dried leaves using the QIAGEN DNeasy plant Mini Kit according to the manufacturer's instruction. DNA was amplified by Polymerase Chain Reaction (PCR), using five universal primer pairs of cpSSR markers. PCR reaction was performed in a volume of 25µl in a DNA thermal cycler. The cpSSR data was visually scored by the presence of specific alleles in each accession at a cpSSR locus. The scored cpSSR data was analyzed as a haploid co-dominant marker for the analysis of total allelic diversity using the POPGENE program version 1.32. The largest fragments amplified from the various cpSSR primers were found in the range of 100 bp to 127 bp while the smallest fragments were found in the range of 50 – 60 bp. Out of the total scored bands, 42.9% bands were polymorphism and 57.1% bands were monomorphic, revealing a low degree of polymorphism. Genetic diversity of C. albidum populations revealed by the use of cpSSR data has indicated that the genetic base of this important tree species has been seriously eroded. Therefore, Urgent steps must be taken by individual, organizations and government to conserve the genetic base of this important tree species.

Keywords: *Chrysophyllum albidum*¸ accessions, simple sequence repeat, genetic variation.

INTRODUCTION

Chrysophyllum albidum G. Don, commonly known as "African Star Apple", is a native to many parts of tropical Africa, widely distributed in West, Central, and East Africa for its edible fruits and various ethno-medical uses (Keay, 1989; Kang, 1992; Amusa *et. al*., 2003; Orwa *et al.*, 2009). This fruit tree grows as a wild plant and belongs to the family Sapotaceae, has up to 800 species and make up almost half of the order (Ehiagbonare *et al.*, 2008). Ecologically, the tree has an efficient nutrient cycling and the high rate of mineralization of the leaves improves the quality of the top soil (Adesina, 2005). It is among the forest tree species that provides Non-Timber Forest Products (NTFPs) of immense domestic importance to rural and urban dwellers in West Africa, with great export potentials (Nwoboshi, 2000). The fruit pulp is widely consumed and thus plays an important role in food security. According to Onyekwelu *et al.* (2011), *C. albidum* fruit serves as a delicacy and alternative source of food, income and rural employment through the collection and sale of the fruits. Other parts of *C. albidum* (such as leaves, seeds, roots and bark) are also used for curing of different diseases such diabetes, ulcer, sterility and sexual weakness, blood pressure, asthma etc. (Houessou *et al.*, 2012).

In Nigeria, *C. albidum* is classified among the endangered tree species (FORMECU, 1999), with a high probability of going into extinction in the near future, which will affect livelihood of millions, especially the rural dwellers that depends on the species as an alternative source of food, medicinal uses and source of household income. *C. albidum* is endowed with a high degree of climatic adaptability. *C. albidum* does not only exist in rainforest, it also thrives well in the savanna where there is less rainfall and high

temperature. The wide geographical and climatic distribution is an indicative of the fact that there exists a tremendous genetic variation, which needs to be identified and catalogued.

Understanding patterns of genetic variation within plant species is of fundamental importance to the development of conservation strategies, both for defining appropriate units for in-situ conservation and for developing effective sample collection strategies for ex-situ conservation (Holsinger and Gottlieb, 1991; Hogbin and Peakall, 1999; Newton *et al.,* 1999). According to Koskela *et al.,* (2007), genetic variation is the fundamental component, which ensures survival and thus the stability of forest ecosystems as its quantity and quality determines the potential of population that will adapt to the changing environmental condition. A large number of studies have been undertaken to assess the extent of genetic variation in threatened plant species (Hamrick *et al.,* 1991; Hamrick and Godt, 1996; Gitzendammer and Soltis, 2000). This reflects the importance accorded to the maintenance of genetic variation in conservation programmes, as its loss may reduce the evolutionary viability of populations by decreasing their ability to adapt to changing environmental conditions (Holsinger and Gottlieb, 1991; Ennos, 1996). More recently, molecular genetic markers based on variation in DNA became commonly applied tools to reveal genetic variation within species and to clarify phylogenetic relations among more or less closely related species, as commonly encountered in the tropical rainforest.

Microsatellite markers are considered the method of choice for this study because of their co-dominant nature, high levels of polymorphism and reproducibility (Weising *et. al.,* 2005) and are more informative than dominant marker data for the estimation of population structure and genetic diversity (Mariette *et. al.,* 2005; Evanno *et. al.,* 2005). The use of Random Amplified Polymorphic DNA (RAPD) markers is not ideal for population genetics, with potential problems of bias (Lynch and Milligan, 1994) and reproducibility between laboratories because of sensitivity to small changes in Polymerase Chain Reaction (PCR) conditions and difficulty in interpretation because of co-migration of brands of similar size (Weising *et. al.,* 2005).

According to FAO (1989), the edible products from these forest tree species are important for food security and have been noted to contain high level of vitamin C, minerals, sugar, proteins, etc, thus playing an important role in the nutritional balance of the people. Onyekwelu and Stimm (2006) also pointed that *C. albidum* serve as source of employment and provide income to household of rural dwellers. Therefore, Urgent steps must be taken by individual, organization and government to conserve this species or to increase their population through domestication.

MATERIALS AND METHODS

Plant Materials

Two juvenile leaves were collected from fifteen accessions of *C. albidum* across Osun State. The leaves were cleaned and preserved with silica gel in sealed nylon and brought to the Biosafety Laboratory of the Federal University of Technology, Akure, Nigeria for DNA extraction. The GPS location of *C. albidum* population sampled in this study were recorded.

DNA Extraction

Total genomic DNA was extracted from 0.020 g powder of silica gel dried leaves using the QIAGEN DNeasy plant Mini Kit according to the manufacturer's instruction (Qiagen Valencia, CA, USA). Also, the concentration of DNA extracted was determined using JENWAY 6305 Spectrophotometer and diluted to 10 ng/µl with ddH20 and stored at -20ºC for PCR amplifications.

PCR Amplifications and Gel Electrophoresis

DNA was amplified by Polymerase Chain Reaction (PCR), using five universal primer pairs of cpSSR markers. PCR reaction was performed in a volume of 25µl in a DNA thermal cycler (Eppendorf, mastercycler gradient). The reaction mixture contained 4µl of 40 ng DNA, 12.5µl of Go Taq Green master Mix, 2x (Promega), 1 µl of each primer and 6.5 µl of Nuclease-free water. The cycling parameters were: 1 cycle of 94ºC for 5mins; 40 cycles of 1 minute denaturing step at 94ºC, 1 minute annealing temperature at 55ºC and 1 minute extension at 72ºC, follow by 15 minutes at 72ºC (post-extension). The PCR products were store at 4ºC until analysis. Amplified PCR products were separated by electrophoresis using 2% agarose gel in 1x TBE (Tris base EDTA) buffer, stained with 5µl ethidium bromide and visualize under UV light. Fragment sizes were estimated using 50-1000 bp Bench Top PCR Markers (ladder – DNA sizing marker).

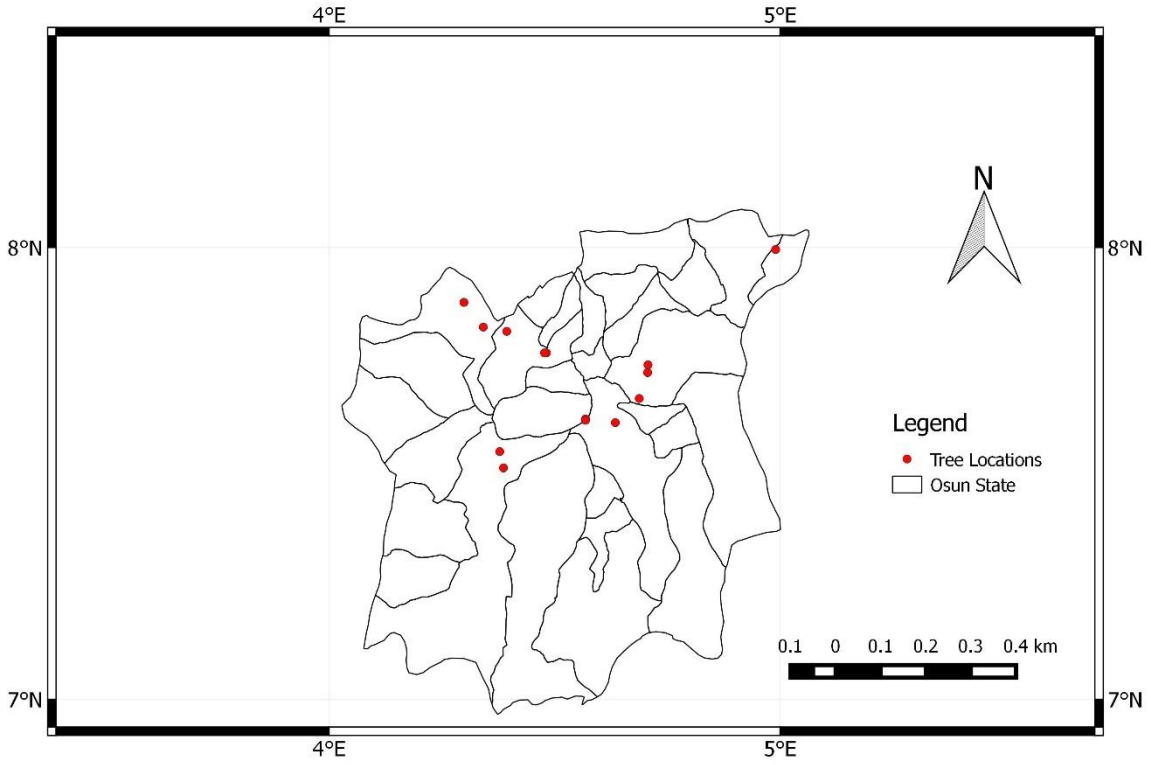


Figure 1: Map of Osun State showing the sampled trees (red dots)

Data Analysis

For cpSSR markers, because of the non-recombining nature of the chloroplast genome, each chloroplast primer pair was considered as 'locus' to refer to a cpSSR site (defined by the terminal of a PCR primer pair) and length variants at a cpSSR site were treated as 'alleles'. The cpSSR data was visually scored by the presence of specific alleles in each accession at a cpSSR locus. The scored cpSSR data was analyzed as a haploid co-dominant marker for the analysis of total allelic diversity using the POPGENE program version 1.32 (Yeh *et. al.,* 1999). The frequencies of the bands were used to calculate the total genetic diversity (h) (Nei, 1978), observed number of alleles (na), effective number of alleles (ne), and Shannon's information index (I). Popgene version 1.31 software (Yeh *et. al.,* 1999) was used to calculate these parameters. Also, the information content of each cpSSR marker was computed as PIC $1 - \Sigma P^2_i$ where P_i is the frequency of the ith band. The average polymorphic information content (PIC) was calculated as described by Sorkheh *et. al.,* (2007). PIC provides an estimate of the discriminating power of a locus by taking into account the number of alleles that are expressed and their relative frequencies. Marker index was calculated as: MI = POL X PIC (POL is polymorphism percentage).

Also, allelic data were analyzed as discrete variables (1) for the presence and (0) for the absence of a similar band. Genetic relationships between the genotypes were calculated using Neighbor-joining. Cluster analysis was done using the sequential agglomerative hierarchical nested cluster analysis (SAHN) procedure of NTSYS (Numerical Taxonomy System), which uses the Neighbor-joining to cluster the genotypes. Obtained results were used to construct a final dendogram showing all accessions using FreeTree version 1.05 and TreeView version 1.6 software.

RESULTS

The largest fragments amplified from the various cpSSR primers were found in the range of 100 bp to 127 bp while the smallest fragments were found in the range of 50 – 60 bp. Out of the total scored bands, 42.9% bands were polymorphism and 57.1% bands were monomorphic, revealing a low degree of polymorphism. The polymorphism information index (PIC, which is the primer's discriminating power) value ranged between 00.0 and 20.0. The highest polymorphic information index (PIC) value was recorded for ccmp2 (20.0). The marker index (MI) values ranged from 0.00 to 1,200. The highest value (1,200) was scored for ccmp2 and the

lowest value (0.00) for ccmp3, ccmp4, ccmp5, and ccmp6 (Table 2). The observed number of alleles, effective number of alleles, Shannon's information index (I), and Nei's genetic diversity for all the accessions was put at 1.60±0.55, 1.22±0.33, 0.14±0.18, and 0.23±0.26 respectively (Table 3). The mean estimate of total gene diversity (H_t), gene diversity due to variation within population (H_s), gene diversity due to differences among populations (G_{st}) and gene flow (Nm*) were 0.1330±0.041, 0.0472±0.002, 0.645, and 0.275 respectively as presented in Table 4.

Table 2: Marker Attributes of Different Chloroplast Simple Sequence Repeat (cpSSR) Primers used in this Study

S/N	Primers	Seq 5' to 3'	Total Bands	Polymorphic bands	POL (%)	PIC	MI
2	ccmp2	Gatcccggacgtaatcctg	5	3	60	20	1200
3	ccmp3	Cagaccaaaagctgacatag	0	0	0	0	0
4	ccmp4	Aatgctgaatcgaygaccta	0	0	0	0	0
5	ccmp5	Tgttccaatatcttcttgtcattt	1	0	0	0	0
6	ccmp6	Cgatgcatatgtagaaagcc	1	0	0	0	0
Mean					10	3	200
Total			7	3	60	20	1200

Note: POL – Polymorphism Percentage, PIC – Polymorphic Information Content, MI – Marker Index

Table 3: Genetic Variability across all the Accessions using cpSSR Markers

Markers	Sample Size	na*	ne*	h*	I*
ccmp2	15	2	1.8000	0.4444	0.6365
ccmp3	15	1	1.0000	0.0000	0.0000
ccmp4	15	2	1.1421	0.1244	0.2449
ccmp5	15	2	1.1421	0.1244	0.2449
ccmp6	15	1	1.0000	0.0000	0.0000
Mean	15	1.6	1.2169	0.1387	0.2253
St. Dev.		0.5477	0.3336	0.1819	0.2605

na = Observed number of alleles, ne* = Effective number of alleles, h* = Nei's gene diversity; and I* = Shannon's Information index*

Table 4: Nei's Analysis of Gene Diversity in Subdivided Populations

Locus	Sample Size	Ht	Hs	Gst	Nm*
ccmp2	15	0.4836	0.1092	0.7742	0.1458
ccmp3	15	0.0000	0.0000	****	****
ccmp4	15	0.0907	0.0635	0.3000	1.1667
ccmp5	15	0.0907	0.0635	0.3000	1.1667
ccmp6	15	0.0000	0.0000	****	****
Mean	15	0.1330	0.0472	0.6448	0.2754
St. Dev.		0.0405	0.0022		

H_t = Total Gene Diversity, H_s = Gene Diversity due to Variation within Populations, G_{st} = Gene Diversity due to differences among Populations; and Nm = Gene flow*

The Neighbor-joining cluster analysis based on Nei's (1978) unbiased genetic distances was performed to further show the genetic relationships among genotypes (Figure 2). The phylogenetic tree depicts the branching history of common ancestry. It showed a

simplicifolious (CaIW15) and a major group. CaIW15, the first branch is genetically different from other trees of the same *C. albidum*. This showed the evolutionary changes that have occurred over time. CaOC1 and CaIN2 shared more recent common ancestor and are more genetically similar. Likewise, CaBO13 and CaOO12 are more genetically related.

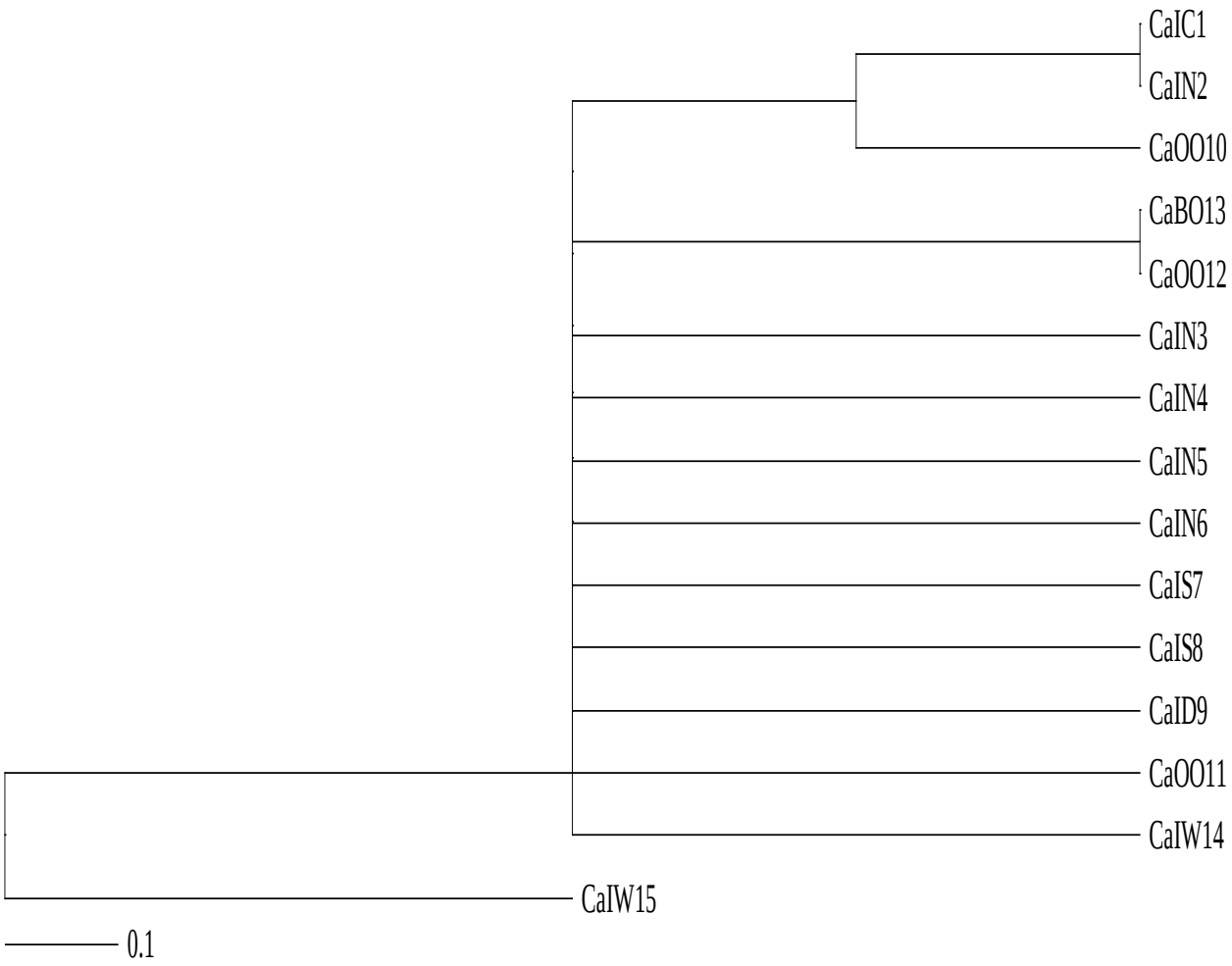


Figure 2: Phylogenetic representation of *Chrysophyllum albidum* population

Note: Ca = Chrysophyllum albidum, IC = Ife Central, IN = Ife North, OO – Odo-Otin, BO = Boripe, IS = Isokan, ID = Ibude, IW = Iwo

DISCUSSION

Plant species, especially the perennials like trees, rely on the available genetic diversity for stability and survival under the ever-changing environments. Population with high level of genetic variation are valuable since they offer a diverse gene pool from which gene conservation and improvement programs can be made (Machua *et. al.,* 2007). The decrease in the genetic diversity limits species ability to keep pace with the changing selection pressure and their roles in the ecological and evolutionary development of the biosphere (Runo *et. al.,* 2004; Machua *et. al.,* 2007). Consequently, maintenance of genetic diversity is important as the diversity carries forward both ecological adaptation and microevolution. *C. albidum* is classified among the endangered tree species in Nigeria (FORMECU, 1999). The over exploitation of *C. albidum* thus threatens their genetic diversity and hence might limit their ecological and evolutionary development of the remaining populations.

The proportion of polymorphic loci (42.9%) detected in this study is indicative of how the genetic base of this species had been eroded. However, variation was observed in the fragment length of the alleles. The mean estimate of G_{st} over all loci was 0.6, which can be interpreted as, 60% of the total genetic diversity in *C. albidum* species is due to differences among populations. Similarly, 40%

of the diversity measured is among trees within populations. Apaprajita and Rout (2008) observed similar genetic pattern for *Albizia lucida* populations using ISSR makers. It revealed a relatively higher level of genetic diversity within populations of *Albizia lucida* and displayed substantial genetic differentiation among *Albizia lucida* population. Likewise, Ude *et. al.,* (2006) also observed genetic diversity within populations of *Irvingia gabonensis* to among populations.

The dendogram constructed revealed genetic variation in *C. albidum* different in the study area. Each branch gives the amount of genetic change and represents the evolutionary change over time. All the trees are from a common ancestor. Although CaIC1 CaIN2 and CaOO10 shared a common ancestor, but CaIC1 and CaIN2 shared a more recent ancestor. According to Hamrick and Godt (1989), species with small geographic ranges tends to maintain less genetic diversity than geographically widespread species. The discrepancy between geographical relationship between CaOO10 and "CaIC1 & CaIN2" suggested that they might have undergone the random changes in genetic composition. These random changes might result in random genetic drift induced by drastic changes in population size and transplantation from other populations for reforestations (Aparajita and Rout, 2008). Drastic environmental changes results in the loss of adaptedness of a particular genotypes. Adaptations are due to genes, that is, they are inherited (Jill *et. al.,* 2011). *C. albidum* species found in the savanna zone could have evolved genetic mechanism to deal with the changes in their environment. The reaction of plants by adjusting its mechanism to changing environmental conditions could be physiological, phenotypic plasticity or both (Finkeldey and Hattemer, 2007).

The extensive genetic differentiation detected among *C. albidum* population has a number of implications for the management and conservation of this species. From a conservation point of view, *C. albidum* in the study area should be managed and maintained separately because they possess partially unique genetic characteristics. In this case, the loss of any population may lead to loss of genetic variation for the species as a whole (Shrestha *et. al.,* 2002). Schaal *et. al.,* (1998) stated that genetic diversity is a prerequisite for future adaptive change and evolution and has a profound effect for species conservation. Conservation measurements should focus on the conservation of *C. albidum* population in or ex situ. In-situ conservation is very useful for preserving inherent diversity to capture the existing local adaptation (Almeida *et. al.,* 2003). Domestication of *C. albidum* in field plots is also proposed as means of conservation utilization that will ensure local people needs for income from the sale of tree products. Domestication will also decrease pressure on the few natural populations and protect its genetic diversity.

CONCLUSION

Genetic diversity of *C. albidum* populations revealed by the use of cpSSR data has indicated that the genetic base of this important tree species has been seriously eroded. Genetic variation among the trees of *C. albidum* reported in this research should be used for both in-situ and ex-situ conservation strategies and effective management of its genetic resources.

RECOMMENDATION

Sustainable strategies should be developed to conserve the genetic composition of the remaining *C. albidum* trees in Osun State, for continuation of genetic variation and adaptation of *C. albidum* trees under various environmental conditions

REFERENCES

Adesina, M.O. (2005). Evaluation of the effect of fruit variation on seed sizes and seedling growth of *Dacryodes edulis* (G.don) M.A Thesis, Rivers State University of Science and Technology, Port-Harcourt, Nigeria. 99pp

Almeida, F.S., Sodre, L.M.K., and Contel, E.P.B., (2003). Population structure analysis of Pimelodus maculates (Pisces, Siluriformes) from the Tiete and Paranapaneme rivers (Brazil). *Gene. Mol.* Biol., 26: 301-305.

Amusa, N.A., Ashaye, O.A and Oladapo, M.O., (2003). Biodeterioration of African star apple (*Chrysophyllum albidumi*) in storage and effect on its food value. *Afr.J.Biotechnol*. 2(3):56-59

Aparajita, S., and Rout, G.R., (2008). Evaluation of genetic differentiation of *Albizia lucida* Populations from eastern region of Indian sub-continent by ISSR markers. *Journal of Forest Science*. Vol 24, pp. 27-34

Cardoso, S.R.S., Eloy, N.B., Provan, J., Cardoso, M.A., Ferreira, P.C.G., (2000). Genetic differentiation of *Euterpe edulis* Mart. Populations estimated by AFLP analysis. *Mol. Ecol*. 9: 1753-1760

Chalmers, K.J., Waugh, R., Sprent, J.I., Simons, A.J., Powell, W., (1992). Detection of genetic variation between and within population of *Gliricidia sepium* and *G. maculate* using RAPD markers. *Heredity* 69, 465-472

Ehiagbonare, J.E., Onyibe, H.I. and Okoegwale, E.E. (2008). Studies on the isolation of normal and abnormal seedlings of *Chrysophyllum albidium*; A step towards sustainable management of the taxon in the 21st century. *Sci. Res Essay*, 3(12), 567–570.

Ennos R.A., (1996). Utilising genetic information in plant conservation programmes. In: Hochberg M.E, Clobert J, Barbault R, eds. Aspects of the genesis and maintenance of biological diversity. Oxford: Oxford University Press, 278-291.

Evanno G., Regnaunts S. and GoudetJ. (2005). Detecting the number of clusters of individuals using the software structure: a simulation study. *Mol Ecol* 14:2611-2620.

Finkeldey R. and Hattemer H. (2007). Evolution and Evolutionary Factors. Troipcal Forest Genetics. ISBN: 3-540-37396-9 Springer-Verlag Berlin Heidelberg New York. 315pp

FORMECU, (1999). Forest Resources Study, Nigeria. Revised national report Vol. 2. Prepared for FORMECU by Beak and Geomatics international, 224pp.

Francisco-Ortega, J., Santos-Guerra, A., Kim, S.C., and Crawford, D.J., (2000). Plant genetic diversity in the Canary Islands: A conservation perspective. *Am. J. Bot*., 87: 909-919.

Gitzendammer M.A., and Soltis P.S. (2000). Patterns of genetic variation in rare and widespread plant congeners. *American Journal of Botany* 87: 783±792.

Hamrick J. L., and Godt M. J.W., (1989). "Allozyme diversity in plants,"in *Plant Population Genetics, Breeding and Genetic Resources*, D.A. H. Brown, M. T. Clegg, A. L. Kahler, and B. S.Weir, Eds., pp. 43–63, Sinauer, Sunderland, Mass, USA.

Hamrick J.L, Godt M.J.W, Murawski D.A, and Loveless M.D. (1991). Correlation between species traits and allozyme diversity: implications for conservation biology. In: Falk DA,

Hamrick J.L, and Godt M.J.W., (1996). Conservation genetics of endangered plant species. In: Avise JC, Hamrick JL, eds. Conservation genetics: case histories from nature. London: Chapman & Hall, 281±304.

Hogbin P.M, and Peakall R., (1999). Evaluation of the conservation of genetic research to the management of endargered plant *Zieria prostrate. Conservation Biology* 13: 514-522

Holsinger KE, eds. Genetics and conservation of rare plants. Oxford: Oxford University Press, 76±86.

Holsinger K.E, and Gottlieb L.D. (1991). Conservation of rare and endangered plants: principles andprospects. In: Falk DA, Holsinger KE, eds. Genetics and conservation of rare plants.
Oxford: Oxford University Press, 195±223.

Houessou, L.G., Toussaint, O.L., Francois, G.H., Lisette, E.S., and Brice, S., (2012). Ethno-botanical study of the African star apple (*Chrysophyllum albidum* G. Don) in the Southern Benin (West Africa). *Journal of Ethnobiology and Ethnomedicine*, 8:40.

Jill, T.A., John, H.W., and Thomas, M.O., (2011). Evolutionary genetics of plant adaptation. *Trends Genet.* 27(7): 258-266

Kang, B. T. (1992). Lecture note: *Multipurpose tree screening and evaluation for agroforestry in thehumid lowland of West Africa*. IITA, Ibadan, Nigeria, pp13.

Keay, R.W.J (1989). Treat of Nigeria Oxford clardon press. 11pp.

Koskela J., Buck A. and Teissier du Cros editors E.,. (2007). Climate change and forest genetic diversity: Implications for sustainable forestmanaement in Europe. *Biodiversity International*, Rome, Italy. pp111

Lynch M. and Milligan B.G. (1994): Analysis of population genetic structure with RAPD markers. *Molecular Ecology*, 3, 91–99.

Machua, J., Muturi, G., and Gicheru, J., (2007). Genetic diversity within *Brachylaena huillensis* (O. Hoffim) populations in Kenya: Implications for conservation of a wood carving tree. J. Discovery Innow., 19: 32-36

Mariette S., LeCorre V., Austerlitz F. and Kremer A. (2005): Sampling within the genome for measuring within-population diversity: tradeoffs between markers. *Molecular Ecology*, 11, 1145–1156

Monteleone I., Ferrazzini D., and Belletti P., (2006). "Effectiveness of neutral RAPD markers to detect genetic divergence between the subspecies *uncinata* and *mugo* of *Pinus mugo* Turra," *Silva Fennica*, vol. 40, no. 3, pp. 391–406.

Muluvi, G.M., Spren, J.I and Soranzo, N. (1999). Amplified fragment length polymorphism (AFLP) analysis of genetic variation in *Moringa oleifera* Lam. *Molecular Ecology* 8, 463-470.

Nei, M. (1973). Analysis of gene diversity in subdivided populations. *Proc. Natl. Acad. Sci. USA* 1973, 70, 3321-3323.

Nei, M., (1978). Estimation of average heterozygosity and genetic distance from a small number of individuals. *Genetics* 89: 583-590

N ewton A.C, Allnutt T, Gillies A.C.M, Lowe A, and Ennos R.A. (1999). Molecular phylogeography, intraspecific variation amd the conservation of tree species. *Trends in Ecology and Evolution* 14: 140-145

Nwoboshi, L.C., (2000). The nutrient factor in sustainable forestry. Ibadan university press, Nigeria, 303pp

Onyekwelu J.C., Stimm B, Monardl, R, and Johnson O. A., (2011). Domestication of *Chrysophyllum albidum* from rainforest and derived savanna ecosystem - phenotype variation and selection of elite trees. *Conf. on Inter. Res. on Food Security, Natural Resource Mangement. and Rural Dev.*

Orwa C, A Mutua, Kindt R , Jamnadass R, S Anthony. (2009). Agroforestry tree Database: a tree reference and selection guide version 4.0 (http://www.worldagroforestry.org/sites/treedbs/treedatabases.asp)

Runo, MS., Muluvi G.M., and Odee, D.W., (2004). Analysis of genetic structure in *Melia volkensii* (Gurke.) populations using random amplified polymorphism DNA. *Afr. J. Biotechnol*. 3: 421-425.

Russel, J.R., Hosein, F., Johnson, E., Waugh, R., and Powell, W., (1993). Genetic differentiation of cocoa (*Theobroma cacao* L.) populations revealed by RQAPD analysis. *Molecular Ecology* 2, 89-97.

Schaal B. A., Hayworth D. A., Olsen K.M., Rauscher J. T., and Smith W. A., (1998). "Phylogeographic studies in plants: problems and prospects," *Molecular Ecology*, vol. 7, no. 4, pp. 465–474,

Shrestha, M. K., Goldhirsh, A. G., and Ward, D., (2002). Population genetic structure and the conservation of insolated populations of Acacia raddiana in the Negev Desert. *Biol. Conserv*. 108, 119-127.

Sorkhen, K., Shiran, B., Gradziel, T.M., Epperson, B.K., Martinez-Gomez, P., and Asadi, E., (2007). Amplified Fragment Length Polymorphism as a tool for molecular characterization of almond, and its relationships with agronomic traits, *Euphytica* 156: 327-344.

Thangjam R., Maibam D., and Sharma J. G., (2003). "Detection of genetic diversity in *Parkia timoriana* (DC.) Merr. using randomly amplified polymorphic DNA analysis," *Journal of Food Agricultural Environment*, vol. 1, no. 3-4, pp. 46–49.

Ude G.N., Dimkpa C.O., Anegbeh P.O., Shaibu A.A., Tenkouano A., Pillay M., and Tchoundjeu Z., (2006). Analysis of genetic diversity in accessions of *Irvingia gabonensis* Aubry-Lecomte ex O'Rorke) Baill. *African Journal of Biotechnology.* Vol. 5 (3), pp. 219-223. ISSN 1684-5315

Weising K., Nybom H., Wolff K. and Khal G. (2005): Applications of DNA fingerprinting in plant sciences. In: *DNA Fingerprinting in Plants: Principles, Methods, and Application*, 2nd edn (eds Weising K, Nybom H, Wolff K & Kahl G), pp. 235–275.

Yeh, F.C., Chong, D.K.S., and Yang, R.C., (1995). RAPD variation within and among natural populations of trembling aspen (*Populus tremuloides* Michx.) from Alberta. *Journal of Heredity* 86, 454-460

Yeh, F.C., Yang, R.C., a Boyle, T., (1999). POPGENE, Version 1.31. CIFOR and Univ. of Alberta, Edmonton, Alberta, 11-27pp

Influence of Seed Minisetts on Germination and Eraly Seedling Growth Performance of *Garcinia kola* Heckel

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ABSTRACT

The aim of this study was to investigate the possible influence of the size of seed minisetts on germination and early seedling growth performance of Garcinia kola with the view to reducing the number of seeds needed for seedling production in the nursery. Seeds of G. kola were cut into minisetts of various sizes (T1= ½, T2= 1/3 and T3 = ¼ of a medium size whole seed) while whole seed (T4) serve as control. Result showed that T4 had highest cumulative germination percentage (CGP) with 80% while T3 had the lowest CGP (46.4%). The early growth of G. kola seedlings were significantly affected by the size of minisetts at p=0.05. The T4 had the highest mean height, collar diameter and number of leaves followed by T1 while T3 had the least values for all parameters measured. It is therefore, recommended that whole seeds of G.kola be sown. If there is shortage in seed supply, seeds could be cut into two as T1 enhanced growth performance.

Keywords: Minisetts technique, *Garcinia kola*, seed germination, growth performance, vulnerable plant

INTRODUCTION

Garcinia kola Heckel trees growing in humid rain forests near the coast are a medium sized and can tolerate shade. It is a well-branched which can grow up to 12m tall and 1.5m wide. It belongs to Guttiferae. It has a regular fruiting cycle and produces a characteristic orange-like pod with edible portion contained in the pod. The seed commonly known as bitter kola is a masticatory used in traditional hospitality cultural and social ceremonies. The species is one of the most important trees in Nigeria for its medicinal value while Olaleye *et al.,* (2000) reported that almost every part of the plant is found to be of medicinal importance and it is also a chewing stick. However deforestation in recent years has drastically reduced the number of these trees growing in the wild. Over last decade, *G. kola* trees have been increasingly cultivated in secondary forest as a component tree in plantations or in agroforestry systems the trees are planted from seed and bear fruit after 10 – 12 years. At its peak a mature tree yields on average 500 fruits and 1700 nuts each year (the Farmer's Voice, 2013).

Seeds are used traditionally to treat various medical ailments such as diarrhoea, hepatitis, asthma, dysmenorrhea, diabetes, anaemia, liver disorders and also as an antidote against ingested poison (Adegoke *et al*, 1981, Dalziel, 1937). More so, Iwu *et al.*,(1999) stated that extracts of various parts of this plant are used for the treatment of laryngitis, mouth infections, cough, heartburn, liver disorders, chest colds hoarseness and other inflammatory diseases. There have also been studies by various authors that have also proven the antimicrobial activities of the seed (Penduki and Okoh, 2011; Njume *et al*, 2011; Sibanda *et al*, 2010, Nwaokorie *et al*, 2010, Akoachere *et al*, 2002). The species is a vulnerable plant and now close to commercial extinction (IUCN, 2004).
To start any selection and improvement programme, seed availability must be considered. As stated above, the seed of *G. kola* has various uses as it has economic value across West African countries and widely traded outside its natural range. This may be having an influence on the decision whether to sow the seeds or not. Without any doubt it is necessary to develop a technique to reduce the seeds used in nursery for seedling production. The seed has certain similar characteristics with yam. This observation led to the use of yam minisett technique reported by Oguntade *et al.*,(2010) to drastically reduced the number of yam tubers used by farmer as 6-33% of the number of tubers required by traditional system . Therefore this study investigated germination of seed minisetts using various sizes and assessing the early growth performance of *G. kola* seedlings with the aim of reducing the number of seeds used in seedling production at the nursery.

MATERIALS AND METHOD

The experimental site was Tree Improvement section nursery of Sustainable Forest Management Department, Forestry Research Institute of Nigeria (FRIN). It lies between Latitude7°24'N and Longitude 3°55'E.
Garcinia kola pods were obtained from a private farm at Ile-Oluji, Ondo State. The fruits were processed and the seeds extracted, cleaned and air-dried for 1 week. The brown seed coat was peeled off and healthy seeds selected for the experiments. The whole seed (T1) had all the seeds un-cut and served as control. Other treatments had their seeds cut into ½ (T2), 1/3 (T3) and ¼ (T4) of a medium sized whole seeds (average seed length = 37.2mm and seed circumference = 19.2mm). T2 had 2 distal ends, T3 had 2 distal ends and 1 middle while T4 had 2 distal ends and 2 middles. The seed minisetts were soaked in distilled water for 48 hours at room temperature. The soaked seeds were then placed in transparent polythene bags and arranged on a shelf close to natural source of light. Each treatment had 10 seeds and the experiment replicated 4 times. Cumulative germination percentage, percentage of un-germinated seeds and percentage of spoilt seeds were considered in the germination experiment. The germinated seed minisetts of relative vigour were potted in 2kg capacity polypots filled with topsoil. Assessment on seedling height, seedling collar diameter and number of leaves were carried out at 4 weeks interval for 6 months. The experiment was arranged in complete randomized design replicated 7 times using single plant replicate. Data generated was subjected to descriptive and analysis of variance while Duncan Multiple Range Test used to separate the means of significant values.

RESULTS AND DISCUSSION

Cumulative Germination Percentage, Mean of Un-germinated and Spoilt Seeds of *G. kola*

From Table 1, it was observed that germination percentage of various seed minisetts ranged between 46.4 and 80. T1 had the highest cumulative germination percentage (CGP) with 80% as none of the seeds were dormant during the time frame of the experiment. T4 had the least CGP value (46.4%) and value of spoilt seeds (7.1%) but recorded the highest value in un-germinated seeds (46.4%). The highest value of spoilt seeds (37.4%) was observed in T2. Seed size is one of components of seed quality affecting the performance of crop (Ambika *et al.*,2014). Generally, bigger seeds germinate quickly when compared to smaller ones (Gunaya et al, 2007). This was evident in the study as whole seeds had best germination performance. Gunaya *et al.*, 2011 recorded highest seed germination in bigger seeds of *Mammea suriga* (79.2%).

Table 1: Cumulative Germination Percentage, Mean of Un-germinated and Spoilt Seeds of *G. kola*

Treatments	Cumulative Germination Percentage (%)	Un-germinated seeds (%)	Spoilt seeds (%)
Whole seed (Control T1)	80	0	20
½ seed T2	56	6.3	37.4
1/3 seed T3	50	44.4	5.6
¼ seed T4	46.4	46.4	7.1

Mean Values of Parameters Measured on Seedling Growth of *G.kola*

Seed is highly important in the life history of tree plants while the physiological and biochemical features in the seed determine the successful establishment of a new young plant in terms of the time it germinates, the place it occupies and its vigour. One of the key features which contribute to success of seed germination and performance is the food reserve it contains (Bewley *et al.*, 2013). The growth performance was significantly affected by the size of minisetts used in this experiment (Table 2). In growth performance assessment carried out (Table 3), T1 recorded the highest height value of 12.2cm which is significantly different from other treatments. T2 followed with 8.6cm while T4 had the least value but not significantly different from T2 and T3. According to table 2, T1 had the highest value in collar diameter assessment with 4.3mm while T3 had the least value (2.4mm). Number of leaves varied with the sizes of seed minisetts used. T1 had the highest value of 5.0, while T3 had the least (3.0). Values of T1 and T2 are not significantly different from each other. In agreement to the finding of this study, Cookson *et al.*, (2001) opined that larger seeds tend to produce more vigorous seedling compared to smaller seeds while Nagaraju (2001) observed higher plant height, number of leaves and stem girth in plants raised from large size seeds. The correlation analysis showed that there were positive relationships between the treatment and the parameters measured (Table 4). Seed minisett sizes had positive relationship with height of the seedlings. This implies that the nearness of the minisett size to the size of the whole seed, the better for the seedling height. That is, bigger the size of the minisetts, the better the growth performance of the seedlings. This applies to all other parameters measured. This may be due to amount of food available to the young plant from the seed. This was buttressed by McNamara and Morse (2014)who reported that an

increase in yam sett size have positive influence on growth performance and even yield of seed yam. Aderounmu and Adegeye (2011) also reported direct positive correlation of *Vitellaria paradoxa* seed size with growth parameters measured.

Table 2: Mean Values of Parameters Measured on Seedling Growth of *G. kola*

Treatments	Means of Parameters Measured		
	Height (cm)	Collar diameter(mm)	Number of leaves
Whole seed (T1)	8.6 ± 0.2^{b}	3.3 ± 0.8^{b}	3.8 ± 0.3^{ab}
½ seed (T2)	7.9 ± 0.2^{b}	3.3 ± 0.7^{b}	3.2 ± 0.2^{ab}
1/3 seed (T3)	7.2 ± 0.2^{b}	2.4 ± 0.7^{c}	3.0 ± 0.2^{b}
¼ seed(T4)	12.2 ± 0.4^{a}	4.3 ± 0.1^{a}	5.0 ± 0.3^{a}

Table 3: Analysis of Variance for Parameters Measured on *G. kola* Seedlings

Source	Dependent Variable	Type III Sum of Squares	Df	Mean Square	F	Sig.
Seed minisett sizes	Height	102.504	3	34.168	12.596	.000
	collar diameter	12.214	3	4.071	19.693	.000
	number of leaves	0.196	3	0.065	3.742	.025
Error	Height	65.103	24	2.713		
	collar diameter	4.962	24	.207		
	number of leaves	0.420	24	0.017		
Total	Height	167.607	27			
	collar diameter	17.177	27			
	number of leaves	0.616	27			

Table 4: Correlation Analysis of the Treatments and Parameters Measured on Seedlings of *G. kola*

	Minisett sizes	Height	collar diameter	Number of leaves
Minisett sizes	1	0.715^{**}	0.807^{**}	0.506^{**}
		0.000	0.000	0.006
	28	28	28	28
Height	0.715^{**}	1	0.597^{**}	0.597^{**}
	0.000		0.001	0.001
	28	28	28	28
collar diameter	0.807^{**}	0.597^{**}	1	0.561^{**}
	0.000	0.001		0.002
	28	28	28	28
number of leaves	0.506^{**}	0.597^{**}	0.561^{**}	1
	0.006	0.001	0.002	
	28	28	28	28

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

CONCLUSION

The focus of this study was to reduce the number of seeds of *Garcinia kola* used in the nursery for seedling production. It can be deduced from the study that use of whole seed performed best. Meanwhile, the various seed minisetts sizes especially seeds cut to half or one-third germinated and performed well also. This technology can be adopted in the nursery.

REFERENCES

Adegoke, E. O Etkin, O. O and Awosika, O. E (1981): Biomedical Evaluation of Commonly Used Plant Medicine. Journal of Ethnopharmacology 4: 75-98 (Pubmed)

Aderounmu, A..F and Adegeye, A.O.(2011): Effect of seed size on germination Of *Vitellaria paradoxa (C.F.Gaertn) Hepper*And early seedling development. Journal of sustainavle environmental management vol.3 53-59

Akoachere J F T K, Ndip R N, Chenwi E B, Ndip L M, Njock T E Anong D N, (2002): Antibacterial Effect of *Zingiber officinales* and *Garcinia kola* on Respiratory Tract Pathogens. East African Med. Journal 79: 588-592

Ambika, S., Manonmani, V. and Somasundaram, G. (2014): review on effect of seed size on seedling vigour and seed yield. Research journal of seed science 7:31-38

Bewley, J. D., Bradford, K., Hilhorst, H.and Nonogaki, H. (2013): seeds: physiology of development, germination and dormancy. Third edition. 183-246

Cookson, W.R., Rowarth, J.S and Sedcole, J.R.(2001): Seed vigour in perennial Ryegrass (*Lolium perenne* L.) Effect and Cause. Seed Sci.Tech.29: 255-270

Dalziel, J. M (1937): The Useful Plants of West Tropical Africa. Crown Agents for the Colonies London U K

I U C N (2004): I U C N Red List of Threatened Species. Red List Category and Criteria www.iucnredlist.org/details

Gunaya, R. P,Haresh, T.S. and Vasudeva, R. (2007): effect of fruit size on early seedling vigour and biomass in white dammer (*Vateria indica*): A vulnerable and economically important tree species of western Ghats.journal of NTFPs 14: 197-200

Gunaya, R. P, Doddabassava, S. and Vasudeva, R (2011): Influence of seed size on germination and seedling growth in *Mamnea suriga* Karnataka J. of Agric Sci. 24: 415-416

Iwu, M (1999): new antimicrobials of plant origin p 456-462 ASHS press alexandria VA

Mc Namara, N. and Morse, S. (2014): working with farmers to produce clean seed yam. YIFSWA working paper series No. 5 49p

Nagaraju, S.(2001): influence of seed size and treatments on seed yield and seed quality of sunflower cv. Morden MSC. Thesis university of Agric Sci. Dharward Kartanataka, India

Njume, C, Afolayan, A. J, Clarke, A .M and Ndip, R. N (2011): Crude Ethanolic Extracs of *Garcinia kola* Seeds Heckel (Guttiferae) Prolong the Lag Phase of Helicobacter Pylori: Inhibitory and Bactericidal Potential Journal of Medicine and Food 14:1-6 (Pubmed)

Nwaokorie, F, Coker A, Ogunsola, F, Gaett- Jardim E Jr. Gabriel, O, Patricia, A, Taiwo, A and Adesola, U (2010): Antimicrobial Activities Of *Garcinia Kola*on Oral Fusa Bacterium Nucleatum And Biofilm. African Journal of Microbiological Resources 4: 509-514

Olaleye, S. B, Faronbi, E .O, Adewoye, E. A and Elegbe, R.A (2000): Analgesic and Anti-Inlammatory Effect of Kalavin (A *Garcinia kola* Seed Extract). Journal of African Biomedical Resources 3: 171-174.

Oguntade, A.E, Thompson, O.A. and Ige, T. (2010): Economics of Seed Yam Production Using Minisett Techniques in Oyo State, Nigeria. Field Acts Science ReportsVol.4, 1-6p.

Penduki, D and Okoli, A .I (2011): In-Vitro Antagonistic Activities Of Crude Dichloromethane Extracts of *Garcinia Kola* (Heckel) Seeds Against Potentially Pathogenic *Vibrio Sp.* Journal of Medicinal Plant Resources 5: 2071-2077

Sibanda, T, Olaniran, L .O, and Okoli, A. I. (2010): Invitro Antibacterial Activities of Crude Extracts Of *Garcinia Kola* Seeds Against Wound Sepsis Associated Staphylococcus Strains Journal Of Medicinal Plants Resources 4: 710-716

The Farmer's Voice (2013) Bitter Cola: Medicinal Values, Extraction, Marketing and Other Uses Newsletter www.thefarmersvoice.org/2.php%3f

Prospects of Biochar in Improving Forest Soil Fertility and Tree Crop Productivity

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ABSTRACT

This paper aimed at creating awareness on biochar technology in relation to tree crops and soil fertility benefits as a biochar initiative in Forestry Research Institute of Nigeria. Biochar (BC) in its natural form is deposited through natural events of forest and grassland fires. As an amendment substance it has been reported to positively impact physical, chemical and biological attributes of soil but limited information exists in Nigeria on its impacts on tree crops. BC is the carbon-rich by-product from anaerobic pyrolysis of biomass that commonly originates from Agriculture and Forestry residues which can improve crop production, forest soil fertility and as a means of sequestering carbon (C). Treatment containing 2.5t/ha PM + 2.5t/ha GSB recorded the highest agronomic growth parameters examined on Entandrophragma utile seedlings at 6 months. Sole or combined application of biochar and urea at 90 kg N/ha override other treatments in providing optimum support for growth of Cocoa and Entandrophragma utile at seedlings stage. The general objective is aimed at sensitizing the stakeholders such as foresters, gardeners, horticulturists, farmers and research scientists in renewable natural resources on the technology. Poultry Manure applied at 5t/ha PM together with Gliricidia sepium (5t/ha GSB) and Tectona grandis (2.5t/ha PM + 2.5t/ha TGB) based biochar are candidate soil additive for raising Entandrophragma utile seedlings in the nursery, for the purpose of plantation establishment for cleaner forestry management. Secondly, application of biochar fortified with little or no inorganic nitrogen could provide unprecedented improvement on Cocoa and Entandrophragma utile seedlings. These can be recommended to tree crop farmers and other stakeholders.

Keywords: Black carbon, tree crop, biochar initiative

INTRODUCTION

Worldwide, there is an increasing interest in biochar (BC) application to Agricultural and Forestry soils to help improve crop production, soil productivity, mitigate global warming, as well as economic empowerment of stakeholders."Biochar" is a relatively new term, yet it is not a new substance. Soils throughout the world contain biochar deposited through natural events, such as forest and grassland fires (Krull *et al.*, 2008, Skjemstad *et al*., 2002). Historical use of biochar dates back at least 2000 years (O'Neill *et al*., 2009). In the Amazon Basin, evidence of extensive use of biochar can be found in the unusually fertile soils known as Terra Preta and Terra Mulata, which were created by ancient, indigenous cultures (O'Neill *et al*., 2009). Due to the large amounts of biochar incorporated into its soils, this region still remains highly fertile despite centuries of leaching from heavy tropical rains. In addition to the studies on the use of biochar for carbon sequestration, a number of reports have focused on alternative applications of biochar for the improvement of soil fertility, plant growth, and decontamination of pollutants such as pesticides, heavy metals, and hydrocarbons (Beesley *et al*., 2011; Cabrera *et al.*, 2011).

The diverse range of biochar applications depends on its physicochemical properties, which are governed by the pyrolysis conditions (heating temperature and duration) and the original feedstock (Enders *et al.*, 2012). Thus, detailed information about the complete production process is a key factor in defining the most suitable application of biochars. The biochar physicochemical properties can cause changes in the soil nutrient and C availability, and provide physical protection to microorganisms against predators and desiccation; this may alter the microbial diversity and taxonomy of the soil (Lehman *et al*., 2011).Soil fertility can be successfully **i**mproved using both inorganic and organic fertilizers. The major drawbacks of inorganic fertilizers are high cost, their low accessibility to resource-poor farmers and their low efficiency in highly weathered soils (Baligar and Benenett, 1986) tendency towards environmental pollution. Organic fertilizer improves nutrient use efficiency, mineralizes easily, increases the organic matter but only lasts for few growing seasons. The complimentary use of biochar with organic or inorganic fertilizer has the tendency of improving soil fertility and tree crop productivity. Plants require organic or inorganic fertilizers for their growth and development. However, inorganic fertilizers pose threats to the environment while organic fertilizers are environmentally friendly. Biochar is also an organic fertilizer, it is a form of charcoal which contains high amounts of carbon and is synthesized by the process of pyrolysis

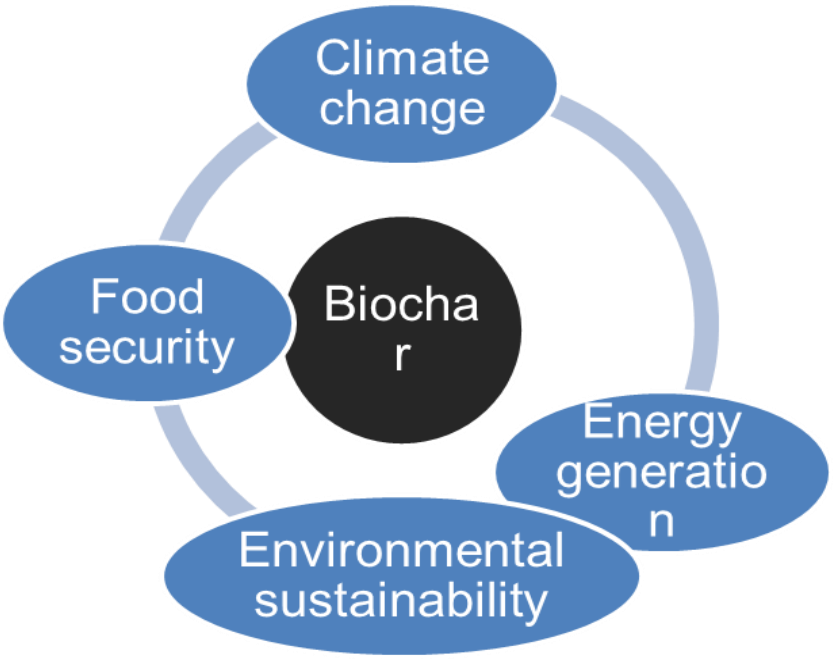
(Pessenda *et al*., 2001) by using raw materials, for example poultry litter (Koutcheiko *et al*., 2007), biomass (Kwapinski *et al*., 2010), corn stover (Brewer *et al*., 2009), switch grass (Brewer *et al*., 2009), hardwood (Brewer *et al*., 2009), citrus wood (Graber *et al*., 2010) and other organic components. It is a more stable form of carbon and does not break easily into components. As a result, it has the ability to remain in soil for hundreds of years (Schmidt *et al*., 2002).

Several reports on the use of biochar on Agricultural crops are documented worldwide but very few have been reported in relation to tree crops. In Nigeria, the available literature even though sparse and mostly based on short-term studies on tree crops hence, further research is still needed to authenticate the benefits of biochar. The objective of this study is to create awareness on biochar technology, instrumentation, production, utilization and to show case few experiments carried on tree species in Forestry Research Institute of Nigeria (FRIN) and to introduce the newly constituted Biochar Initiative of Nigeria (BIN) to farmers, research scientists and other stakeholders.

Definition of Biochar

Biochar (BC) is the carbon-rich by-product from anaerobic pyrolysis of biomass that commonly originates from agriculture and forestry residues. It is a highly porous fine grained charcoal like material that is produced from non-hazardous waste materials. BC is also known as pyrolysed organic matters. It is the carbon-rich product obtained when biomass, such as wood, manure or leaves, is heated in a closed container with little or no available air (Lehmann and Joseph 2009). 'Biochar'' is a term recently coined as a label for charcoal intended for use as a soil amendment, generally derived from organic waste feedstocks such as sawmill or crop residues. Biochar has received substantial attention as a means to enhance carbon sequestration in managed ecosystems (Lehmann and Joseph 2009; Woolf *et al.*, 2010). Biochar is a plant derived biomass that is produced by a process of pyrolysis (charring) that has been converted into a form that is essentially non-degradable. Biochar can be produced as a sole product or a byproduct of a range of pyrolysis or gasification technologies (Yeboah, 2016)

The centrality of Biochar Technology



Melissa *et al.*, 2012

Biochar Production

Biochar is produced by thermal decomposition of organic material under limited supply of oxygen (O_2), and at relatively low temperatures (<700°C) (Lehmann and Joseph 2009). This production method is called pyrolysis. Pyrolysis is thermal degradation of biomass in the absence of oxygen, which results in the production of biochar, biofuel, and biogas (syngas) products. Pyrolysis is a thermo-chemical decomposition process in which organic material is converted into a carbon-rich solid and volatile matter by heating

in the absence of oxygen (Demirbas and Arin, 2002). The solid, termed variously as char, biochar, charcoal or coke, is generally of high carbon content and may contain around half the total carbon of the original organic matter. The volatiles can be partly condensed to give a liquid fraction leaving a mixture of so-called 'non-condensable' gases.

Pyrolysis is defined as the thermal decomposition of organic material through the application of heat without the addition of extra air or oxygen. It involves the simultaneous change of chemical composition and physical state of an organic material into an irreversible state. Biochar can be produced from various types of processes including slow and fast pyrolysis, and gasification. Each type of process is distinguished by different ranges of temperatures, heating rates, biomass and vapour residence times. Given this variability in pyrolysis processes and their accompanying process conditions, in combination with a wide range of available biomass feedstocks for biochar production (including wood, energy crops, agricultural waste residues, sewage sludge, anaerobic digester, municipal wastes, etc.), large variability is to be expected in the physico- chemical properties of the biochars, and ultimately, in their performance as a soil amendment and/or in their ability to store carbon permanently in the soil (Antal and Gronli, 2003). Consequently, the challenge for biochar science is to predict and assure product quality, agronomic benefits and environmental effects of any given biochar produced from any given feedstock by any given pyrolysis technology and process conditions (Masek *et al.*, 2011). Biochar Production Units: Biochar production facilities can be designed for small, medium and large scale production. It ranges from stove technology, Kiln: traditional kiln and steel kiln; Retorts, Converters and Reactors. (Onwuka, 2016). The production facilities could be fabricated e.g charcoal fired, electricity powered and LPG/LNG
reactors (Odesola, 2016)



Plate1: Electricity powered Biochar Reactor



Plate 2: Charcoal /Briquette fired Biochar Reactor

Feedstock for biochar Production

Large amounts of agricultural, municipal and forestry biomass are currently burned or left to decompose and release CO_2 and methane back into the atmosphere. They also can pollute local ground and surface waters—a large issue for livestock wastes. Using these materials to make biochar not only removes them from a pollution cycle, but biochar can be obtained as a by-product of producing energy from this biomass. Feedstocks must not contain unacceptable levels of toxins such as heavy metals which can be found in sewage sludge and industrial or landfill waste. The biomass or feedstock use in biochar production includes a wide range of the following:

Agricultural crop residues: rice husk, cocoa pod husk, Bambara nut pods, coconut husk, empty palm bunches, maize crop residue;

Forest residues: sawdust, tree barks, woodchips, off cuts, spent mushroom substrate, bamboo, *Gliricidia sepium;*

Animal wastes: poultry manure, cowdung, horse dung, bones, feather;

Domestically generated wastes: kitchen based wastes Non-hazardous organic industrial wastes among others.

Benefits of biochar

At present, the mechanisms by which biochar increases soil fertility are not fully understood. Research has demonstrated that biochar application to soil increases the soil organic carbon, improves water holding capacity and soil aeration, increases the cation exchange capacity, neutralizes the pH of acidic soils and improves the soil microbial ecology (Sohi *et al.*,2010). In addition to these purported benefits, biochar largely consists of a recalcitrant carbon fraction which has been demonstrated to be very stable, with a half-life of over 1000 years in the soil (Lehmann *et al.*, 2006; Kuzyakov *et al.*, 2009; Lehmann and Joseph, 2009; Zimm- erman, 2010). Consequently, biochar production by pyrolysis of biomass effectively removes carbon from the atmospheric carbon cycle, transferring it to long- term storage in soils. Biochar therefore could help in the global challenge of carbon dioxide (CO2) mitigation, as it results in a net removal of carbon from the atmosphere (Lehmann *et al.*, 2006; Lehmann and Joseph, 2009).

SPECIFIC TRIALS TO VALIDATE SOME OF THESE CLAIMS IN FORESTRY RESEARCH INSTITUTE OF NIGERIA (FRIN)

The effect of Poultry manure, NPK (15:15:15), Maize Crop Residue and *Gliricidia sepium* based biochar on the growth and dry matter yield of *Entandrophragma utile* seedlings in the greenhouse was evaluated by Adejoh *et al.*, 2016. The experiment was laid out in a completely randomized design with 8 replicates. Data on growth of *Entandrophragma utile* seedlings were taken for 6 months. The treatments consisted T1: 2.5t/ha *Gliricidia sepium* based biochar (GSB), T2: 5t/ha GSB, T3: 7.5t/ha GSB, T4: 2.5t/ha *Tectona grandis* based biochar (TGB) T5: 5t/ha TGB,T6: 7.5t/ha TGB , T7: 2.5t/ha Poultry Manure(PM) T8: 5t/ha PM , T9: 7.5t/ha PM, T10: 2.5t/ha PM+ 2.5t/ha GSB, T11: 2.5t/ha PM + 2.5t/ha TGB and T12: Control.

RESULTS

Biomass weight of *E. utile* seedlings at 6 months

The highest root collar diameter (7.39mm), total leaf number (10.13) and leaf Area (256.04cm2) were recorded by 2.5t/ha PM + 2.5t/ha GSB, respectively (Figure 1). The correlation coefficients (0.853) indicate that strong and significant association exists between growth parameters examined. Also, strong (positive) and significant association (0.980) exists between wet weight and dry weight. Poultry Manure applied at 5t/ha PM together with *Gliricidia sepium* (5t/ha GSB) and *Tectona grandis* (2.5t/ha PM + 2.5t/ha TGB) based biochar are candidate soil additive for raising *Entandrophragma utile* seedlings in the nursery for the purpose of plantation establishment for cleaner forestry management. This can be recommended to tree crop farmers and other stakeholders.

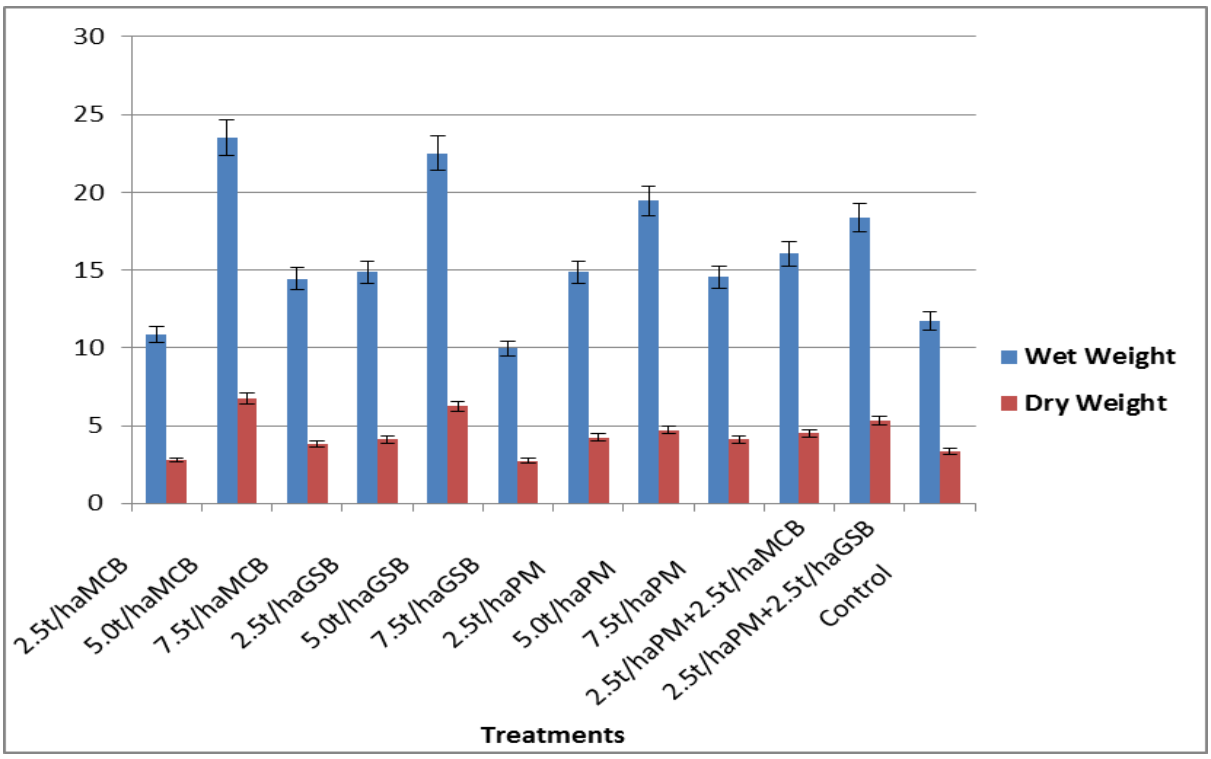


Fig. 1: Biomass weight of *E. utile* seedlings at 6 months

Afolabi and Akinrinde, 2016 evaluated the influence of biochar, green manure, urea and their combinations on growth of *Theobroma cacao* L. and *Entandrophragma utile* Dave & Sprague seedlings. The screen house trial involved 75 seedlings each of the two tree species. The treatments applied were *Leucaena leucocephala* biochar (LLB), *Leucaena leucocephala* green leaf manure (LLGM), urea and their combinations (LLB + LLGM, LLB + urea and LLGM + Urea) in ratio 1:1 and at four nitrogen levels (45, 90, 135 and 180 kg N/ha) together with a control (No fertilizer application) in three replicates.

Effects of soil amendments on biomass of cocoa and *E. utile* seedlings at 24 weeks after transplanting

The research effort provided an insight to growth responses of the tree crop and *E. utile* as might be on the field. Both species responded positively to various N-rates of soil amendments applied. Sole or combined application of biochar and urea at 90 kg N/ha override other treatments in providing optimum support for growth of the trees at seedlings stage (Figure 2). Therefore, application of biochar fortified with little or no inorganic nitrogen could provide unprecedented improvement on the crop if adopted by farmers.

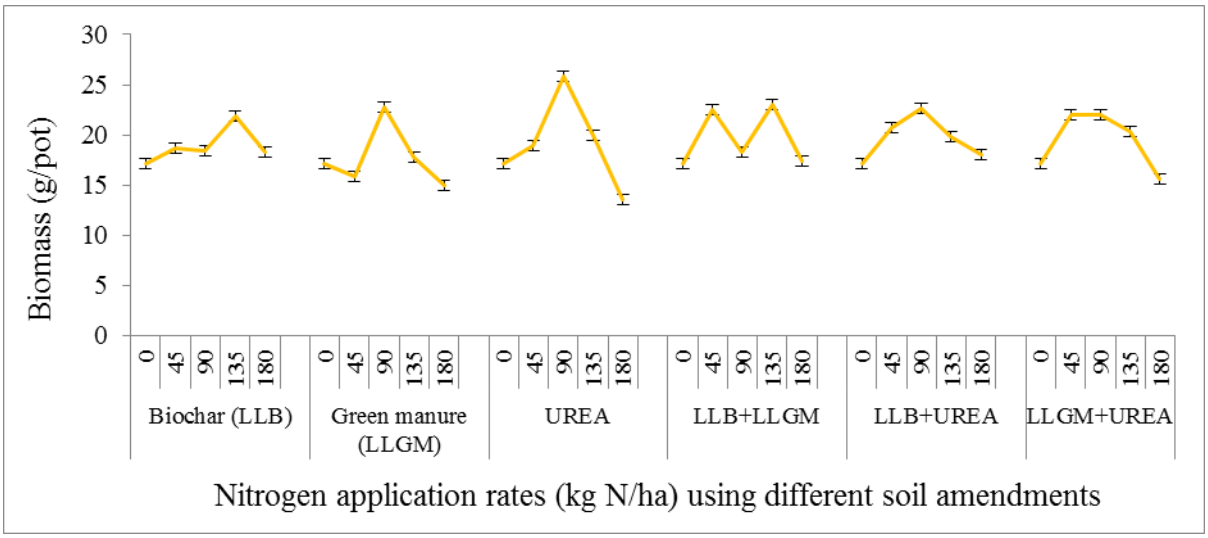


Fig 2: Effects of soil amendments on biomass of cocoa and *E. utile* seedlings at 24 weeks after transplanting

CONCLUSION AND RECOMMENDATION

Biochar technology has the potential to improve crop production, soil productivity, enhance a cleaner environment and mitigate climate change due to high carbon content in the soil conditional. The approach of biochar technology offers a possibility of turning waste to wealth, while agricultural residue and forest biomass are readily available, cheap, sustainable and environmentally friendly.

There is urgent need for integrated research on biochar in relation to tree crops in Nigeria, which is in line with the sustainable development goals .The support for biochar research, development and transfer of technology to farmers and other stakeholders must be strengthened at the national level in Nigeria.

REFERENCES

Adejoh, O.P., Fagbenro J.A., Okubena- Dipeolu E.A., Afolabi, J.O and Ihediuche, C.I (2016) Early growth of *Entandrophragma utile* (Dave & Sprague) seedlings with biochar and Poultry Manure for cleaner forest Management. Book of Abstracts for the second Annual Conference of the Biochar Initiative of Nigeria. Sept 6-9, Bowen University, Iwo, Osun State. Pp 28.

Afolabi, J.O and Akinrinde E.A (2016) Response of Theobroma cacao (L) and *Entandrophragma utile* (Dave & Sprague) seedlings to biochar, green manure and urea on an Alfisol at Ibadan, Nigeria. Book of Abstracts for the second Annual Conference of the Biochar Initiative of Nigeria. Sept 6-9, Bowen University, Iwo, Osun State. Pp 13

Antal, M.J., Jr.; Grønli, M (2003) The art, science, and technology of charcoal production. Ind. Eng. Chem. Res 42: 1619–1640.

Baligar, V.C. and Bennett, O.L. (1986) NPK-fertilzer efficiency—A situation analysis for the tropics. Fertilizer Research, 10: 147-164.

Beesley, L., Moreno-Jiménez, E., Gomez-Eyles, J. L., Harris, E., Robinson, B., and Sizmur, T (2011) A review of biochars' potential role in the remediation, revegetation and restoration of contaminated soils, Environ. Pollut., 159: 3269–3282

Brewer, C. E., Schmidt-Rohr, K., Satrio, J. A., and Brown R. C (2009). Characterization of biochar from Fast pyrolysis and gasification systems, Environ. Prog. Sustain. Energy, 28: 386–396

Cabrera, A., Cox, L., Spokas, K. A., Celis, R., Hermosín, M. C., Cornejo, J., and Koskinen, W. C (2011) Comparative sorp- tion and leaching study of the herbicides fluometuron and 4- chloro-2 methylphenoxyacetic acid (MCPA) in a soil amended with biochars and other sorbents, J. Agri. Food Chem., 14: 12550–12560,.

Enders, A., Hanley, K., Whitman, T., Joseph, S., and Lehmann, J (2012). Characterization of biochars to evaluate recalcitrance and agro- nomic performance, Bioresource. Technol., 114: 644–653

Graber E.R, Harel Y.M, Kolton M, Cytryn E, Silber E, David D.R, Tsechansky L, Borenshtein M, Elad Y (2010). Biochar impact on development and productivity of pepper and tomato grown in fertigated soilless media. Plant Soil: 337, 481-496.

Koutcheiko S, Monreal CM, Kodama H, McCracken T, Kotlyar L (2007). Preparation and characterization of activated carbon derived from the thermo-chemical conversion of chicken manure. *Bioresource. Technol*. 98: 2459-2464.

Krull, E.S., J. Lehmann, J. Skjemstad, and J. Baldock (2008). The global extent of black C in soils; is it everywhere? In: Hans G. Schroder (ed.), Grasslands; ecology, management and restoration. New York: Nova Science Publishers, Inc. p. 13–17

Kuzyakov, Y., Subbotina, I., Chen, H., Bogomolova, I., Xu, X (2009b). Black carbon decomposition and incorporation into soil microbial biomass estimated by 14C labeling. Soil Biology & Biochemistry 41: 210-219.

Kwapinski W, Byrne C.M.P., Kryachko E., Wolfram P., Adley C., Leahy J.J, Novotny E.H., Hayes M.H.B (2010). Biochar from biomass and waste. Waste Biomass Valor. 1:177-189.

Lehmann J, Rillig M C, Thies J, Masiello CA, Hockaday WC, Crowley D (2011). Biochar effects on soil biota: a review. Soil Biol. Biochem. 43:1812-1836.

Lehmann, J. (2007). Bio-energy in the black. Frontiers in Ecology and Environment 5:38–387.

Lehmann, J. and M. Rondon (2006). Bio Char soil man- agement on highly weathered soils in the humid tropics. In: N. Uphoff et al. (eds.), Biological approaches to sustainable soil systems. Florida: CRC Press, Taylor and Francis Group. Pp. 517–530.

Liang, B., J. Lehmann, D. Solomon, S. Sohi, J.E. Thies, J.O. Skjemstad, F.J. Luizao, M.H. Engelhard, E.G. Neves, and S. Wirick (2008). Stability of biomass derived black carbon in soils. Geochimica et Cosmochimica Acta 72:6096–6078.

Niklaus E. Zimmermann, Thomas C. Edwards Jr., Catherine H. Graham, Peter B. Pearman and Jens-Christian Svenning (2010) New trends in species distribution modelling: Ecography 33: 985 -989.

O'Neill, B., J. Grossman, M.T. Tsai, J.E. Gomes, J. Lehm- ann, J. Peterson, E. Neves, and J.E. Thies (2009). Bacterial community composition in Brazilian Anthrosols and adjacent soils characterized using culturing and molecular identification. Microbial Ecology 58:23–35.

Onwuka, M.I (2016) Biochar: The hidden wealth in waste. Book of Abstracts for the second Annual Conference of the Biochar Initiative of Nigeria. Sept 6-9, Bowen University, Iwo, Osun State. Pp 6

Pessenda L.C.R, Gouveia S.E.M, Aravena R (2001). Radiocarbon dating of total soil organic matter and humin fraction and its comparison with 14C ages of fossil charcoal. Radiocarbon. 43, 595-601.

Schmidt M.W.I, Skjemstad J.O, Jager C (2002). Carbon isotope geochemistry and nanomorphology of soil black carbon: Black chernozemic soils in central Europe originate from ancient biomass burning. Glob. Biogeochem. Cycles, 16: 1123.

Schnug, E., Heym, J., Achwan, F., (1996). Establishing critical values for soil and plant analysis by mean of boundary line development system (Bolides). Communication of Soil Science and Plants Analysis 27 (13 and 14), 2739–2748.

Skjemstad, J.O., Reicosky, D.C., Wills, A.R. and McGowan J.A (2002). Charcoal carbon in U.S. agricultural soils. Soil Science Society of America Journal 66:1249–1255.

Sohi, S. P., Krull, E., Lopez-Capel, E. and Bol, R (2010). A review of biochar and its use and function in soil Pp. 47-82 Advances in Agronomy, Vol 105. Advances in Agronomy. San Diego, Elsevier Academic Press Inc.

Woolf, D., J.E. Amonette, F.A. Street-Perrott, J. Lehmann, and S. Joseph. (2010). Sustainable biochar to mitigate global climate change. Nature Communications 1, Article number: 56 (online journal).www.nature. com/ncomms/journal/v1/n5/full/ncom

SUB-THEME 4

Forest Governance Issues

Challenges of Forest Policy Implementation and Problems associated with Forest Plantation Management in Southwestern Nigeria

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ABSTRACT

Forest policy implementation (FPI) is a fundamental strategy for realising sustainable Forest Plantation Management (FPM). However, in some designated forest reserves in the Southwestern Nigeria, FPI has been inadequate and lacks proper coordination for achieving the goal of Forest plantation. Therefore, challenges of FPI and problems associated with FPM in Southwestern Nigeria were investigated. Simple random sampling (SRS) was used to select 238 forest officials (FOs) representing 25% sampling intensity in the States: Ekiti (27), Lagos (12), Ogun (89), Ondo (55), Osun (26) and Oyo (29). SRS was also used to select 1,377 Forest Dwellers (FDs) from adjoining communities in 12 purposively selected forest plantations across six States: Ekiti (147), Lagos (129), Ogun (305), Ondo (226), Osun (350) and Oyo (220). Two sets of structured questionnaire were used to obtain data on challenges of FPI and problems associated with FPM. Data were analysed using descriptive statistics, Chi-square and logistic regression at $\alpha_{0.05}$*. Respondents were 45.2±11.5 years, mostly male (84.1%); 41.9% had secondary education while 28.8% had only primary education. There was significant association between lack of funds; skilled personnel/staff shortage; lack of effective supervision, coordination and control; political instability; ill-equipped forestry institutions to carry out their functions; and FPI. Problems associated with FPM included lack of staff training and re-training, illegal logging activities, functional patrol vehicles and adequate land for forest expansion with odd-ratios of 262831, 946.1, 49.1 and 18.5, respectively. The crucial logistics needed for successful FPI are inadequate in the region while the existence of some key problems affecting FPM was also confirmed. However, there is an urgent need for the forestry service to address the identified challenges required for proper FPI and provide staff training/re-training, control illegal logging activities, purchase functional patrol vehicles and reserve adequate land for forest expansion for effective FPM in Southwestern Nigeria.*

Keywords: Forestry service, forest plantation, management problems, forest dwellers

INTRODUCTION

In view of the failure of Tropical Shelterwood System (TSS) and partial jettisoning of enrichment planting, direct plantation development was adopted as a method of developing the forest resources. Direct plantation development is the management system of developing the forest resources in which the existing vegetation is totally or partially removed and new crops are planted in place (Adetula, 2002). Forest plantation plays a vital role in economic development of the state. The forest provides household food and shelter for the people (Omorodion and Ebana, 1994). However, effective plantation management becomes imperative to ensure sustained yield. Meanwhile, in ensuring continuity in the dividends of effective plantation management, it becomes pertinent to consider both near and long term measures based on policy instruments, being canvassed for adoption by countries, organisations and individuals in ensuring sustained yield production of forest resources through effective plantation management.

In the light of the above, the importance of forest policy in effective plantation management to ensuring continuity in production of forest resources cannot be over-emphasized. Arifalo (1990) affirmed that forest is an important component of man's environment and if properly managed, can provide myriad benefits like sources of foreign exchange earnings, employment, housing materials etc. It also provides ecological benefits like clean air, a sanctuary for wildlife, erosion control, stream flow regulation, and provision of a wholesome environment.

A well implemented forest policy is therefore needed to enable the society to continue to have an uninterrupted access to forest goods and services. If there is lack of an operational forest policy, it is not unlikely that the present generation will unwittingly liquidate the

forest base to the great disadvantages of the succeeding generation. In that circumstance, forest policy provides the framework for the use and replacement strategy of the forest, so that from time to time; the society has access to forest goods and services (Agbeja, 2010).

Different actors play a role in formulating and implementing a forest policy. This depends on the socio-economic-political system of the country. Regardless of the form of government, one must understand that forest policy implementation requires the participation and acceptance of the stakeholders as well as that of government agencies and officials. Hence, forest policy implementation constitutes an index for measuring the efficiency of the forestry departments. This study therefore evaluates the challenges confronting forest policy implementation viz-a-viz problems associated with forest plantation management in Southwestern Nigeria. This is with a view to harmonising mitigations strategy towards ensuring sustained yield production of forest resources.

METHODOLOGY

Study Area

The study area is southwestern Nigeria which consists of Ekiti, Lagos, Ogun, Ondo, Osun and Oyo States. It is also known as the southwestern geographical zone of Nigeria (Figure 1). The area lies between longitude $2^{0}31^{1}$ and $6^{0}00^{1}$ East and Latitude $6^{0}21^{1}$ and $8^{0}37^{1}$N (Agboola, 1997) with a total land area of 77,818km2 and a current population of 27,721,832 (NPC, 2006). They are notable as the major timber producing states in the past and also in the present. They are also notable for employment of latent labour locked up in the rural areas. The study area is bounded in the East by Edo and Delta states, in the North by Kwara and Kogi States, in the West by the Republic of Benin and in the south by Gulf of Guinea.



Figure 1: Map of Nigeria showing the study area

Data Collection and Analysis

The study population was made up of core forest officials (Professional, Technical and Uniform staff) and people living in the forest's adjoining communities. Hence two sets of structured questionnaire were used. Simple random sampling was used to select 238 forest officials representing 25% sampling intensity in the states: Ekiti (27), Lagos (12), Ogun (89), Ondo (55), Osun (26) and Oyo (29). Complete enumeration was done in Lagos State due to limited number of forest official available in the State forestry service. To collect data from the forest dwellers, 12 forest plantations were purposively selected in the six states (2 plantations per state). Ogbese and Eda were selected in Ekiti, Ogun River and Badagry in Lagos, Omo and Olokemeji in Ogun, Oluwa and Oyinmo in Ondo, Shasha and Ipetu/Ikeji in Osun and Onigambari and Oko/iroo in Oyo. The communities in and around the forest plantations within 2-3Km radius were identified. Among the identified communities, 5 communities were randomly selected per plantation, except in Lagos State where they are limited in number (Figure 2). Precisely, only four (4) of such were found in Ogun River while none was found in Badagry due to enchroachment. The method of Diaw *et al.* (2002) was adapted to select 1,377 forest dwellers from the sampled adjoining communities in 12 purposively selected forest plantations across the six states: Ekiti (147), Lagos (129), Ogun (205), Ondo (226), Osun (350) and Oyo (220). Data collected were subjected to descriptive statistics which involve frequency analysis, percentage and charts. Also a non-parametric inferential statistics such as chi-square test, and Logistic regression analysis were used.

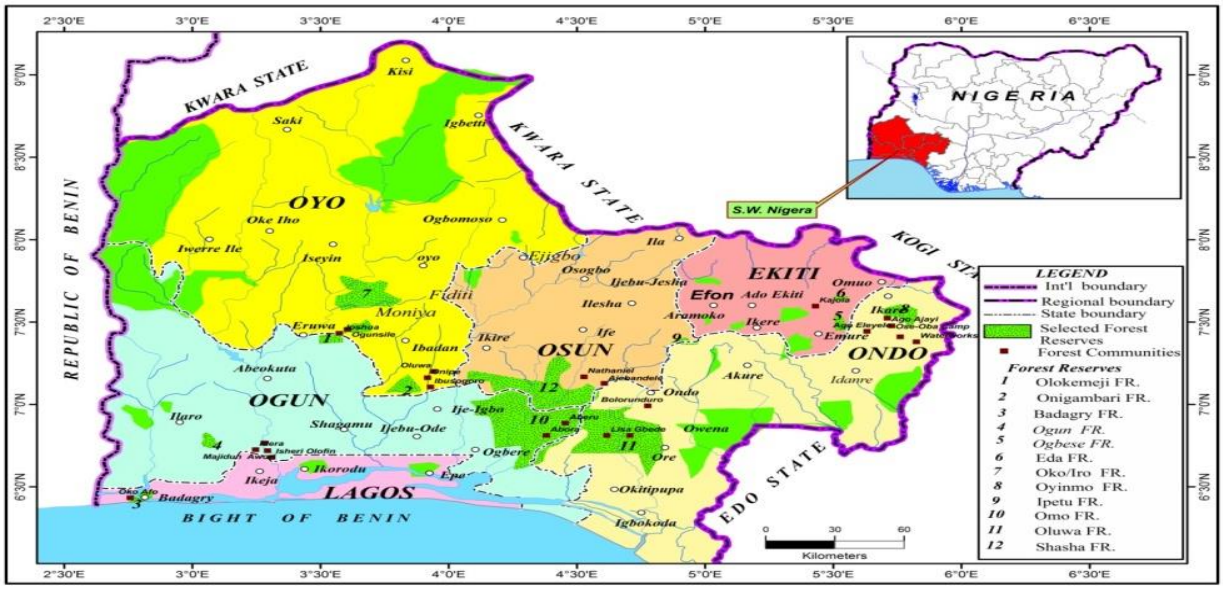


Figure 2: Map of Southwestern Nigeria showing selected forest reserves and some adjoining communities

RESULTS AND DISCUSSION

Total Number of Respondents (forest officials) in the Southwestern Nigeria

A total of 238 structured questionnaire were administered to the State Forestry staff, 203 were duly filled and returned to the investigator. The returns represent 85.29% of the total number of questionnaire given to the forestry staff in the Southwestern Nigeria (Table 1).

Total number of respondents (forest dwellers) in the Southwestern Nigeria

For the study carried out among the people living in the forest plantations' adjoining communities, a total of 1,337 well-structured questionnaire were administered to the forest dwellers and 1244 were duly filled and returned to the investigator. The returns represent 93% of the total number of questionnaire given to the forest dwellers in the Southwestern Nigeria (Table 2).

Table 1: Total Number of Respondents (forest officials) in the Southwestern Nigeria

Location	Frequency	Percentage
Ekiti	27	13.30
Lagos	8	3.94
Ogun	68	33.50
Ondo	46	22.66
Osun	26	12.81
Oyo	28	13.79
Total	203	100

Source: Field Survey, 2014.

Table 2: Total Number of Respondents (forest dwellers) in the Southwestern Nigeria

Location	Frequency	Percentage
Ekiti	134	10.77
Lagos	124	9.97
Ogun	272	21.87
Ondo	204	16.40
Osun	318	25.56
Oyo	192	15.43
Total	1244	100

Source: Field Survey, 2014.

Demographic Information of Respondents in the Southwestern Nigeria (forest officials and forest dwellers)

Personal characteristics of the respondents discussed are gender, age and educational attainment. Table 3 showed that most of the respondents were males (84.10%) and the respondents (36.62%) were between 41-50 years of age followed by 32.13% that correspond to 31-40 years. The average age of the respondents was 45.2 ± 11.5 years. The table also revealed that 41.95% of the respondents have secondary education; 28.82% have primary education; 17.14% have tertiary education and 12.02% have no formal education. It could be inferred from this study that stakeholders in forestry are predominantly men and this could be as a result of the laborious nature of most forestry activities. The majority of the respondents were adults. This is a clear indication that responses were obtained from experienced individuals. It could also be inferred from the study that both the forest dwellers and non-forest dwellers (forest officials) were able to access basic education which is a pointer to the fulfilment of the education for all agenda of the Federal Republic of Nigeria. In other words, in spite the location of forest reserves and the accessibility problems associated with such locations, schools for basic education could still be easily accessed by the residents.

Table 3: Demographic Information of Respondents (forest officials and forest dwellers) in Southwestern Nigeria

Demographic parameters	Frequency	Percentage
Gender		
Male	1133	84.10
Female	314	15.90
Age distribution		
21-30	103	7.85
31-40	420	32.13
41-50	506	36.62
51-60	251	13.80

61-70	99	3.98
Above 71	45	1.81
None response	23	3.81
Educational distribution		
Tertiary education	248	17.14
Secondary education	607	41.95
Primary education	417	28.82
No formal education	174	12.02
None response	1	0.07

Source: Field Survey, 2014

Challenges of Forest Policy Implementation in Southwestern Nigeria

Lack of Finance to Carry out Forestry Programme

Figure 3 revealed that all the states in the Southwestern Nigeria agreed that forestry programmes are not given priority in terms of funding. The pooled data in Southwestern Nigeria indicated that 94.1% of the respondents agreed that there had been lack of finance to carry out forestry programmes while 1.5% disagreed. The remaining 4.4% were silent on this issue. The result of chi-square test clearly showed that lack of finance to carry out forestry programme had significant association with forest policy implementation in the study area (χ^2=20.79, p<0.05). In order for the state forest services in Southwestern Nigeria to perform and fulfil their mandate, adequate funding is a must. In other words, the success in any programme implementation depends solely on finance. Faleyimu (2010) affirmed the need for funding in form of loans, subsidies or other kinds of financial assistance for successful implementation of forestry programmes.

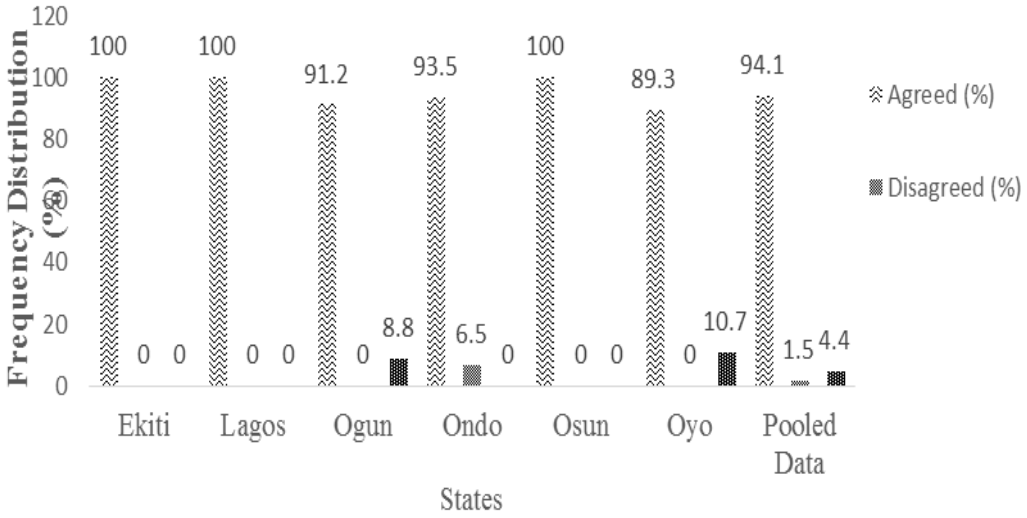


Figure 3: Frequency distribution of forest officials' perception on lack of finance to carry out forestry Programme

Shortage of Skilled Personnel

Figure 4 revealed that 70.4% of the respondents are of the opinion that there had been shortage of skilled personnel/staff while 28.6% disagreed and just 1% remained silent on this issue. The result of chi-square test clearly showed that shortage of skilled personnel/staff to carry out forestry programme have significant association with forest policy implementation in the study area (χ^2=19.25, p<0.05). Hence, there was inadequate skilled personnel/staff in all the states in the study area, in fact, the case of Lagos State is a serious one meanwhile successful forestry programme requires adequate personnel as skilled personnel helps the forest service to grow technologically. According to Investopedia (2016), skilled labour or personnel is a segment of the work force with a high skill level that creates significant economic value through the work performed (human capital). The pooled data in Southwestern Nigeria

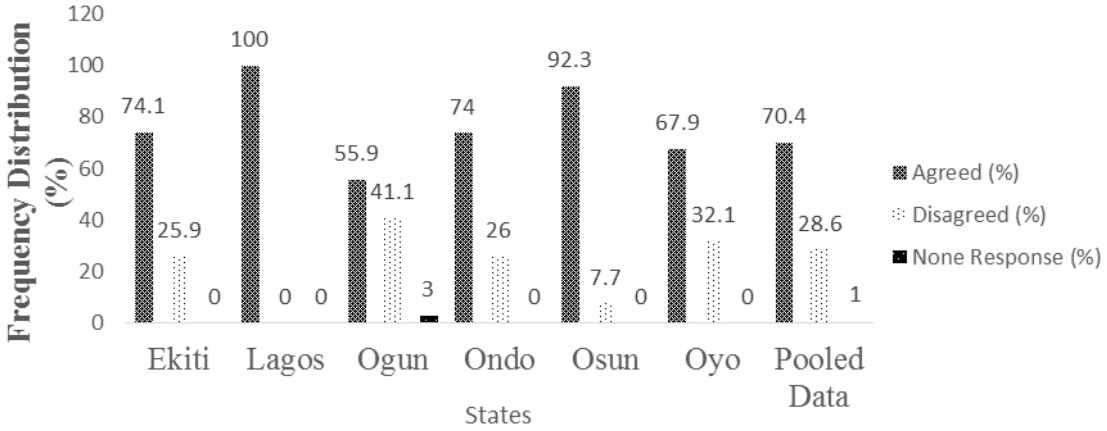


Figure 4: Frequency distribution of forest officials' perception on shortage of skilled personnel/staff

Lack of Effective Supervision, Co-ordination and Control

Figure 5 revealed that 100% of the respondents in Lagos State agreed that effective supervision, co-ordination and control in carrying out forestry programmes were lacking in their state while the reverse was the case in Oyo State as 64.3% of the respondents disagreed. This result negated the finding of Faleyimu and Agbeja (2012) which observed that inefficient supervision and co-ordination is a major problem of forest policy implementation in Southwestern Nigeria except in Lagos and Ogun States. The pooled data from the Southwestern Nigeria indicated that 64.5% of the respondents agreed that there had been ineffective supervision, co-ordination and control of forestry programmes and reserves while 33.5% disagreed. The result of chi-square test revealed that lack of effective supervision, co-ordination and control programmes had significant association with forest policy implementation in the study area (χ^2=31.45, p<0.05). Hence, the study established that ineffective supervision, co-ordination and control were major challenges confronting forest policy implementation in the study area.

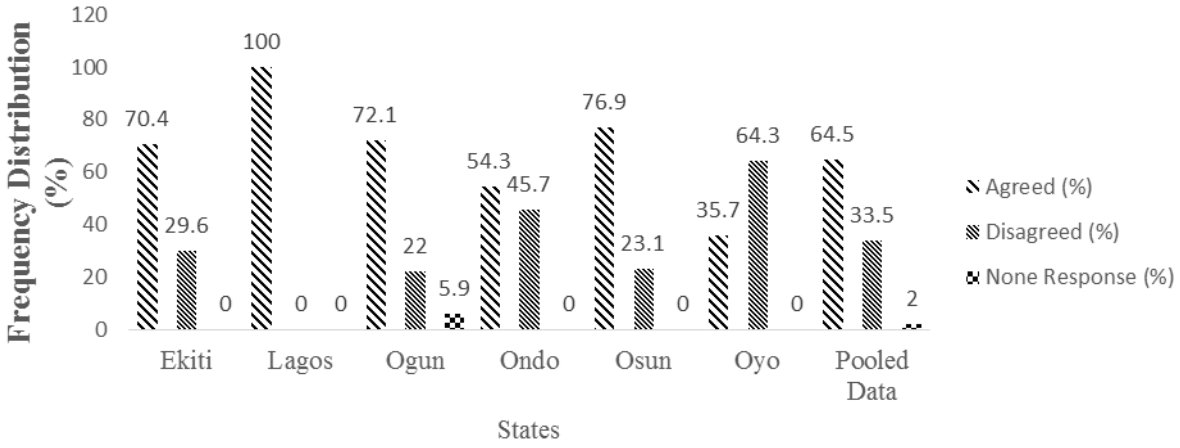


Figure 5: Frequency distribution of forest officials' perception on lack of effective supervision, co-ordination and control

Political Instability

Figure 6 showed that 64.3% of the respondents in Oyo State disagreed with the fact that political instability is responsible for ineffective forest policy implementation while 35.7% agreed. The pooled data from the Southwestern Nigeria indicated that 64.5% of the respondents agreed that political instability is affecting effective forest policy implementation while 33.5% of the respondents disagreed. The result of chi-square test revealed that indeed, political instability had significant association with forest policy implementation in the study area. (χ^2=27.96, p<0.05). This study agrees with the finding of Faleyimu (2010) and also confirmed the report of Akindele (2001), that governments in some states interfere in forest management often by approving forest exploitation to generate more revenue without due regard for conservation or sustainability of the resource. He further stated that there have been cases of undue interference from officers who are superior to the Director of Forestry. These officers include the permanent secretary (or Director General), the commissioner and the State Governor (or Military Administrator). Mostly in Nigeria, policies are changed to suit politicians' immediate gain while frequent policy changes result in increased risks and provide a climate of insecurity for investors. In some countries, frequent changes of government have resulted in repeated changes in policies and the erosion of support mechanisms (Durst et al. 2001). This also affects forestry sector.

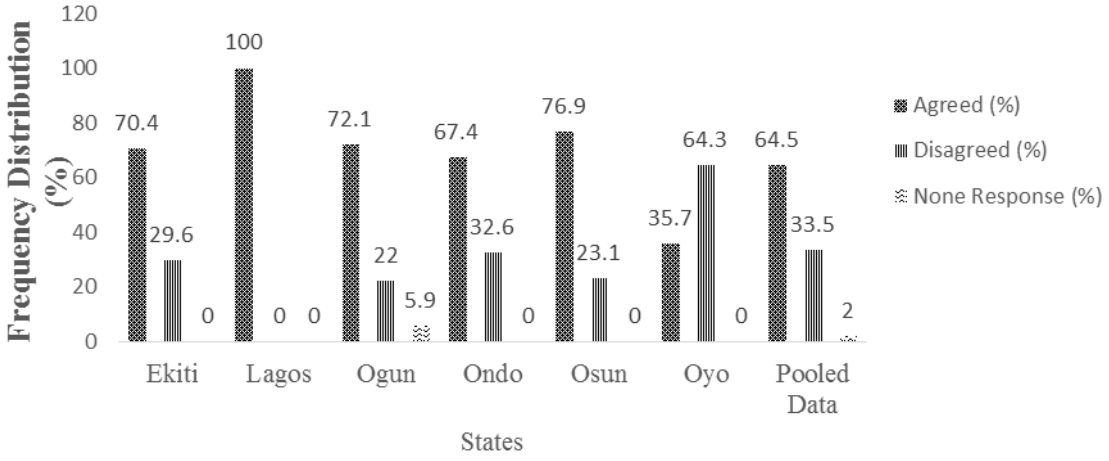


Figure 6: Frequency distribution of forest officials' perception on political instability

Ill-Equipped Forestry Institutions to carry out their Functions

The pooled data from Southwestern Nigeria (Figure 7) revealed that 78.3% of the respondents agreed that ill-equipped forest service is a challenge of forest policy implementation while 19.7% disagreed and 2% did not respond. The result of chi-square test clearly showed that ill-equipped forest service has significant association with forest policy implementation in the study area. (χ^2=19.364, p<0.05). This study agrees with Akindele (2001) who reported that as a result of poor funding, the departments of forestry cannot acquire new field vehicles and equipment and there is no substantial expansion in the forest estate.

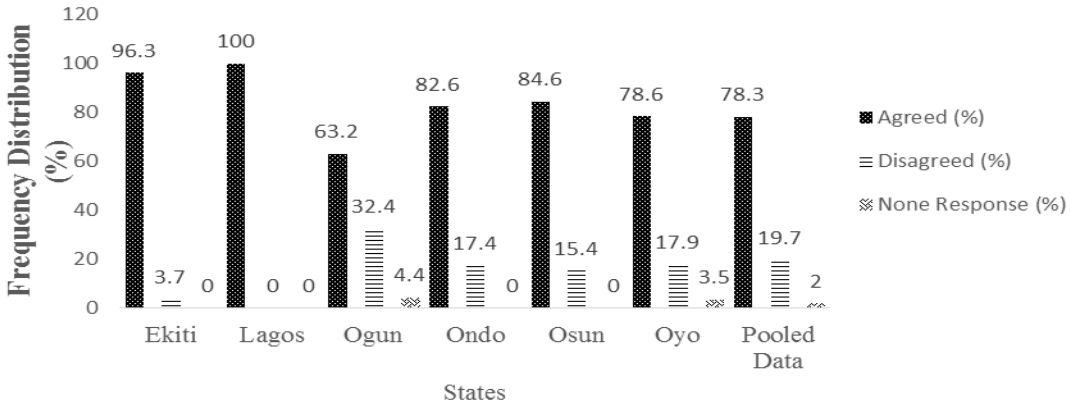


Figure 7: Frequency distribution of forest officials' perception on ill-equipped forestry institutions to carry out their functions

Problems Associated with Plantation Management

Logistic regression model for plantation management adequacy in the Southwestern Nigeria

The stakeholders' (Forest officials and forest dwellers) data were pooled together on plantation management adequacy.

The binary models

Binary regression models obtained for the plantation management adequacy in the Southwestern Nigeria (Table 4):

$$PMA = 2.730 - 9.029F + 0.028TA - 39.870FFFE - 1.400FT + 3.893FPV - 2.263SR + 12.5STR + 6.852ILA + 2.918ALFE + 37.353RSMO$$

--------(Equation 1)

N= 1447, Final loss= 105.566, Chi- square (df, 10) = 1706.2, P=0.0000

Odd ratio (Unit change): Constant (7.133); F (0.000); TA (1.029); FFFE (0.000); FT (0.247); FPV (49.063); SR (0.104); STR (262831); ILA (946.068); ALFE (18.511); RSMO (0.000).

Where, PMA = Plantation Management Adequacy.
F = Funding.
TA = Technical Assistance.
FFFE = Functional Fire Fighting Equipment.
FT = Functional Tractors.
FPV =Functional Patrol Vehicles.
SR = Staff Recruitment.
STR = Staff Training and Re-training.
ILA = Illegal Logging Activities.
ALFE = Adequate Land for Forest Expansion.
RSMO = Regular Silvicultural Management Operations.

Table 4: Logistic Binary Nature of Plantation Management Adequacy in Southwestern Nigeria

Dependent variable (PMA) = Plantation Management Adequacy (Yes =1; No = 0).

Independent variables	Coefficient	Odds-ratio
Whether presence of (F) will make plantation management adequate.	-9.029	0.000ns
Whether presence of (TA) will make plantation management adequate.	0.028	1.029ns
Whether presence of (FFFE) will make plantation management adequate.	-39.870	0.000ns
Whether presence of (FT) will make plantation management adequate.	-1.400	0.247ns
Whether presence of (FPV) will make plantation management adequate.	3.893	49.063*
Whether presence of (SR) will make plantation management adequate.	-2.263	0.104ns
Whether presence of (STR) will make plantation management adequate.	12.5	262831*
Whether presence of (ILA) will make plantation management adequate.	6.852	946.068*
Whether presence of (ALFE) will make plantation management adequate.	2.918	18.511*
Whether presence of (RSMO) will make plantation management adequate.	-37.353	0.000ns
Model χ^2(df,10)= 1706.2, Final loss = 105.566; p<0.05		

*= significant at p<0.05; ns= Not significant

Model presented above for Southwestern Nigeria gave overall significant fit to the data judging from χ^2 value that was significant at $p< 0.05$. Staff Training and Re-training (STR) had the highest odd-ratio of 262831 followed by Illegal Logging Activities (ILA) with the odd-ratio of 946.068, Functional Patrol Vehicles (FPV) with the odd-ratio of 49.063 and lastly, Adequate Land for Forest Expansion (ALFE) with the odd-ratio of 18.511 respectively. Therefore, the problems identified to be confronting adequate forest plantation management in the Southwestern Nigeria are lack of adequate Staff Training and Re-training (STR), prevailing Illegal Logging Activities (ILA), Lack of Functional Patrol Vehicles (FPV) and Adequate Land for Forest Expansion (ALFE). There was sufficient evidence that the estimated coefficients for the factors were not zero. This implies that the regression parameters in the model were statistically significant. In other words, the higher the value of odd-ratios, the more likelihood the factors (Problems) affecting adequate forest plantation management in the Southwestern Nigeria. Hence, it clearly indicated the variable (s) i.e factors that mostly influence adequate forest plantation management in the Southwestern Nigeria. The implication was corroborated by Deeks (1996); Bland and Altman (2000) that the logistic model provides information on the consequences of one variable on the other. Therefore, the lack of these factors poses serious challenges to achieving adequate forest plantation management in the study area.

CONCLUSION AND RECOMMENDATIONS

The study confirmed that the challenges facing forest policy implementation are lack of finance, shortage of skilled personnel, lack of effective supervision, co-ordination and control, political instability and ill-equipped forestry institutions. There were variations in the factors identified to be confronting adequate forest plantation management in the study area. Nevertheless, adequate staff training and re-training was the most significant, followed by illegal logging activities, lack of functional patrol vehicles and adequate land for forest expansion. Therefore, there is a need for the six forest departments to address these problems for effective forest management.

Hence, government should provide forest officials with the necessary financial support, and equipment to enable them carry out their work promptly and effectively. More skilled personnel should be recruited in the state forestry service in Southwestern Nigeria, especially in Lagos State. Forestry programmes should be thoroughly supervised and co-ordinated in the region while training and retraining of staff should be ensured as such would enhance their productivity. There should be continuity in implementation of forestry programmes by the state government irrespective of political affiliations and lastly, the six states' forestry department should control illegal logging activities, purchase functional patrol vehicles and reserve adequate land for forest expansion.

REFERENCES

Adetula, T. 2002. Forest Resources Development in Nigeria, Ondo State: a case study. Forestry and Challenges of Sustainable Livelihood. (Eds. Abu, J.E, Oni, P.I, Popoola, L.). In the *Proceedings of 27th Annual Conference of Forestry Association of Nigeria* held in Akure, Ondo State, 4th-8thNovember, 2002. P.40.

Agbeja, B.O. 2010. Forest policy and Forest Products Marketing in Nigeria: Implications for Forestry Sector. Climate Change and Forest Resources Management: The way forward. In: J.C. Onyekwelu, V.A.J. Adekunle and D.O. Oke (Eds).*Proceedings of the 2nd Biennial Conference of the Forests and Forest Products Society* held in Akure. (FUTA), 26th-29th April, 2010. P477.

Agboola, S.A. 1997. *An Agricultural Atlas of Nigeria*. Oxford University Press Nigeria.

Akindele, S.O. 2001. Review of Urgent Management Requirements for Nigerian Forestry. Forestry and National Development. (Eds: Popoola, L., Abu, J.E. and Oni, P.I). In: The *Proceedings of the 27th Annual Conference of Forestry Association of Nigeria* held in Abuja, Nigeria, 17-21st Sept, 2001. Pp. 75-84.

Arifalo, E.I. 1990. Forest Ecosystem Stability in Nigeria, the New Nigerian Newspaper, Kaduna. Saturday 16th June, 1990. Pp8-9.

Bland, J.M. and Altman, D.G. 2000. "The odds ratio" British Medical Journal 230, 1468

Deeks, J. 1996. *Swots Corner: What is an Odds Ratio*? Banddolier, 3(3), Issue 25, 6-7.

Durst, P.B., Waggener, T.R., Enters, T. & Tan, L.C. (eds) 2001. *Forest Out of Bounds: Impacts and Effectiveness of logging Bans in Natural Forests in Asia-Pacific*. RAP Publication: 2001/08. Bangkok, Food and Agriculture Organization of the United Nations. Pp1-3.

Faleyimu, O.I. 2010. Status of Forest Policy Implementation in South-West Nigeria. An Unpublished Ph.D Thesis. Submitted to the Department of Forest Resources Management, University of Ibadan. PP 212-221.

Faleyimu, O.I and Agbeja, B.O. 2012. Constraints to Forest Policy Implementation in the South-West Nigeria: Causes, Consequences and Cure. *Journal of Resources & Environment* 2012, 2(2): 37-44. DOI: 10.5923/j.re.20120202.06. Pp.37-44.

Investopedia. 2016. Skilled Labour. http://www.investopedia.com/terms/s/skilled-labor.asp. Accessed 5th July, 2016.

NPC 2006. National Population Commission 2006, Abuja, Nigeria.

Omorodion, F. I. and Ebana, R. 1994. The Impact of Deforestation in Cross River State of Nigeria. 16p. Report Prepared for Cross River State. Forestry Project (ODA Assisted).

Adaptive Strategies of Deforestation Employed by (NTFPs) Collectors in Okomu Forest Reserve, Edo State, Nigeria

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ABSTRACT

The study examined the adaptive strategies of deforestation stress employed by NTFPs collectors in Okomu Forest Reserve of Edo State, Nigeria. A proportionate sampling method was used to select a sample size of 132 respondents while data were collected with the aid of a structured questionnaire and analysed using descriptive statistics. The data analysis targeted socio-economic characteristics, types of NTFPs, level of deforestation stress and adaptive strategies to deforestation. Findings revealed that average age of male and female respondents was 42 years. Bitter Kola and Kola nut were the major NTPFs in the study area. Most (63.6%) of the respondents indicated a high level of deforestation stress in the study area. Domestication of NTPFs, regular monitoring and employment of guards were common adaptation strategies utilised by respondents. The study recommended the need for public enlightenment and awareness among rural dwellers as well as forest users on forest and environmental conservation practices.

Keywords: Adaptive strategies, deforestation, forest reserve, non-timber forest products

INTRODUCTION

Forest is an essential natural resource, both for the survival and prosperity of humanity, and for the maintenance of all terrestrial ecosystems. This invaluable renewable natural resource is beneficial to man in many ways. The resources in the forest yield direct and indirect benefits. Direct benefits include: fuel wood, timbers, bamboos, food, shelter, paper products, rayon, other forest products (Tannins, gums, drugs, spices, insecticides, waxes, honey, horns, musk, ivory, hides etc) are all provided by the flora and fauna of forests. The indirect benefits include: conservation of soil, soil-improvement and reduction in atmospheric pollution.

Furthermore, rural dwellers in the forest environments generally depend on natural resources for their survival. One of such activities is the gathering of Non-Timber Forest Product (NTFPs). Affirming this, Aluko, Adejumo and Samuel (2015) opined that most forest dwellers engage in gathering and marketing of NTFPs as a means of livelihood. Similarly, Offiong and Ita (2013) reported that Non-timber forest products formed an integral component of the livelihood strategy of rural dwellers in the tropics as well as an important fact of household nutrition in Africa.

However, Non timber forest products (NTFPs) contributes sustainably to nutrition either as parts of the family diet on as means to achieve household food security by serving as a means of income generation that will empower the household to purchase their required household diet demand (Shackleton and Shackleton, 2004). This suggests that NTFPs contributes immensely to the overall wellbeing of households. However, the natural resources in the forest are relatively scarce owing to deforestation. FAO (2004) defined deforestation as the conversion of forested land to other uses, or a permanent reduction of canopy cover. Deforestation has continued to affect livelihood activities of dwellers in forest settlement (Acheampong and Marfo, 2011). According to Osalusi, *et al* (2011) NTFPs are not spare in the process of deforestation as its availability keeps reducing alongside the trees that support them. In view of this, it becomes quite difficult for forest dwellers who solely rely on gathering of NTFPs as a means of livelihood .Hence, the need to examine the adaptation strategies to deforestation stress with the view of promoting sustainable forest management and community based forest management in such a way that would protect land and people as well as provide opportunities for greater, more sustainable rural development and poverty alleviation through income generation and employment opportunities becomes imperative.The objectives of the study were to: describe the socio-economic characteristics of the Non-Timber forest products farmers , identify the various NTFPs, examine the extent to which respondents are exposed to deforestation stress and identify the adaptation strategies to deforestation stress in the study area

METHODOLOGY

Study Area

The study was carried out in Okomu Forest Reserve; it is located at Udo communities in Ovia South West Local Government Area of Edo State Nigeria. It is situated between latitude 6.3333^{o}N and longitude 5.26667^{o}E. It occupies an area 200m^{2} of land and was established in the year 1935. Okomu lies on undulating land and the most part of altitude is between 60.96 and 121.92m above sea level except for rugged quartzite ridge near the western side. Multistage sampling method was used in carrying out the research. There are nineteen villages/settlement around the reserve comprising, Udo, Okomu, Ofunama, Igue-lahor, A. T and P, Oral, Arakhuan, Nikrowa, Izede-Noke, Nanen, Iguobazuwa, Iguogun, Iguomo, Iguoriakhi, Okoro, Okopon, Ogba, Okada.

Data Collection and Procedure

Four villages/settlements were purposively selected due to high involvement in collection of NTFP. The selected villages are Okomu, Udo, Okada, and Iguobazuwa. Base line survey was carried out in the selected villages/settlement. 500 household were identified in Okomu, 600 in Udo, 880 in Okada and 650 in Iguobazuwa through participating rural appraisal. Five percent of the household heads were randomly selected across the settlements to give 25 from Okomu, 30 from Udo, 44 from Okada and 33 from Iquobazuwa. This gives a sample size of 132 respondents

Table 1: Population of selected communities with households

Selected communities	Total number of household heads	5% of selected household heads
Okomu	500	25
Udo	600	30
Okada	880	44
Iguobazuwa	650	33
Total	2,630	132

Source: Field Survey, 2015

RESULTS AND DISCUSSION

Socio-economic Characteristics of Respondents

Table 1 revealed that gender distribution of the respondents was about 62.9% for male, while 37.1% were female. This implies that male headed households were more engaged in producing NTFPs. This is in line with Brian (2012) submission who suggested that household headed by male participated more in NTFPs than those headed by female. Also, age distribution of the respondents shows that most (47.7%) of the respondents were between 40-49 years. This suggests that the middle age people are into NTFPs production. This is also in line with Akanni (2013) findings on the subject. The results also show that 31.1% were single, 54.9% were married, 7.6% were divorced while 6.8% were widowed. This implies that most of the respondents were married and shoulders one form of responsibility or the other. About 25.0% of the respondents had no formal education, 48.5% had primary school certificate and 22.7% had secondary education while 3.8% of the respondents were with tertiary education. This shows that large proportion of the respondents had at least primary education in the study area. The marketing categories of the respondents' shows that 18.9% of the respondents sell NTFPs to their co-villagers, 28.0% to nearby villagers, 45.4% of the respondents sell to the people from the urban part of the state while 7.7% of them sells to the people from other states. This suggests that there is a high demand for NTFPs in urban areas. The results also show that 44.0% of the respondents sell their products in wholesales, 33.1% as middle men while 22.7% as retailers. The socio-economic characteristic of respondents therefore shows that rural dwellers in the community depend solely on NTFPs which formed the basis of their livelihood and sustenance. This result is in line with Ogundele *et al.,* 2012 who posited that rural dwellers involve in NTFPs to sustain their livelihood.

Table 2: Socio-Economic Distribution of the Respondents

Variable	Frequency	Percentage
Gender		
Male	83	62.9
Female	49	37.1
Total	132	100.0
Age (years)		
Below 40	56	42.4
40-49	63	47.7
50-59	11	8.3
60years and above	2	1.6
Total	132	100.0
Marital status		
Single	41	31.1
Married	72	54.5
Divorced	10	7.6
Widowed	9	6.8
Total	132	100.0
Level of education		
No- formal	33	25.0
Primary	64	48.5
Secondary	30	22.7
Tertiary	5	3.8
Total	132	100.0
Consumer categories		
Same villagers	25	18.9
Nearby villagers	37	28.0
Urban part of the state	60	45.4
Other states	10	7.7
Total	132	100.0
Selling mode		
Wholesale	58	44.0
Retail	30	22.7
Middlemen	44	33.3
Total	132	100.0

Source: Field Survey, 2015

Non Timber Forest Products

Table 3 revealed that the most (79.5%) of the respondents indicated Kolanut as most available NTFPs. This can be attributed to the fact that people in the study area make use of Kola nut for religious and ceremonial activities. Bitter kola and bamboo were ranked second and third respectively among the NTFPs in the study area. Medicinal herbs, Fuel wood, Broom were also available in the study area. This suggests that respondents in the study area were engaged in the gathering of NTFPs. In line with this finding, Adebayo and Akindele (2003) maintained that forests are common property resource that plays a crucial role in rural livelihood. It therefore, supports subsistence and income generating activities.

Table 3: Non-Timber Forest Products

Types	Response	
	Yes (%)	No (%)
Broom	88(66.7)	44(14.6)
Mushroom	96(72.7)	36(27.3)
Fuel wood	88(66.7)	44(33.3)
Medicinal herbs	99(75.0)	33(25.0)
Kola nut	105(79.5)	27(20.5)
Bitter kola	103(78.0%)	29(22.0)
Bamboo	101 (76.5)	31(23.5)

Source: Field Survey, 2015.

Level of Deforestation Stress in the Study Area

Table 4 shows that dwellers in the study area experienced deforestation stress. It was revealed that majority (63.6%) of the respondents considered deforestation stress are a serious issue while 9.8% believed it is a very serious issue. The remaining 26.6% did not see it as an issue on the level of availability of NTFPs in the study area. This is an indication that respondents in the study area perceive the problem of deforestation to be a threat to their livelihood survival.

Table 4: Level of deforestation of availability of NTPFs

Level of experience	Freq.	%
Very serious	13	9.8
Serious	84	63.6
Not serious	35	26.6

Source: Field Survey, 2015.

Adaptation Strategy to Deforestation Stress

Result on table 4 shows that larger proportion of the respondents employed domesticated NTFPs at their backyards or plot of lands that are not around forest reserve (mean = 2.51) while regular monitoring of NTFPs in the reserved were ranked second with mean value of 2.33. This according to the respondents helps them to collaborate with the timber concessionaires who sometimes spare the NTFPs during their activities. Another strategy employed by the respondents is that of employment of guards. This is to guide against illegal tree fellers from encroaching into the reserve to cut both timber and non-timber in the reserve. Traditional method which involved making signs, drawing occultic symbol on NTFPs was ranked fourth with the mean value of 1.97. The respondents also adapt to the problem of deforestation by going deep into the thick forest where human activities are at minimal level.

Table 4: Distribution based on the adaptation

Adaptation strategies	Mean	Rank
Domestication of NTPFs	2.51	1
Traditional spiritual method	1.97	4
Regular Monitoring	2.33	2
Employed Guards	2.13	3
Migration to another forest	1.24	6
Identified NTPFS in thick Forest	1.33	5

CONCLUSION AND RECOMMENDATION

The study observed that rural households were involved in NTFPs gathering for sustaining their livelihood. However, NTFPs in the study area were under threat of deforestation. In an attempt to reduce the effects of deforestation on availability of NTFPs all year round, rural households were compelled to develop some adaptation strategies so as to respond to the changing environmental circumstances. Thus, the study observed that the survival attitudes caused by deforestation have encouraged rural households in coming up with multiple adaptation strategies such as domestication of NTFPs , regular monitoring of NTFPs in the reserved areas, employment of guards and traditional methods like making signs and drawing occultic symbol.

Since NTFPs serves as means of sustaining livelihood among rural households, the study recommended the need for public enlightenment and awareness among rural dwellers as well as forest users on forest and environmental conservation practices.

REFERENCES

Acheampong, E. and E. Marfo (2011). "The impact of tree tenure and access on chainsaw milling in Ghana." *Ghana Journal of Forestry*, Vol. 27: 68-86.

Adebayo, A.G and Akindele S.O (2003) : Appraisal of Forest Resources Utilization and its Impact on Rural Household Poverty in Kwara State, Nigeria. Nigeria Journal of Forestry 33(1) 11-17

Akanni K.A (2013): Economic Benefits of Non-Timber Forest Products Among Rural Communities in Nigeria, *Environment and Natural Resources Research;* Vol. 3, No. 4; 2013, ISSN 1927-0488, Published by Canadian Center of Science and Education

Aluko O.J, Adejumo A.A. and Samuel O.F, (2015). Impact of conflicts on` marketing of selected non timber forest products around Omo forest reserve Ogun state Nigeria. Proceedings of'XVI Forestry World Congress in Durban South Africa. 7-11 September, 2015

Aluko, O.J. Abegunrin O.O. Ajetomobi, O.O. and Osalusi, C.S. (2012): Impact of Displacement on Livelihood Activities of Dwellers in Omo Forest Reserves. *Proceeding 6th Annual Conference on Research and Capacity Building for Agricultural Transformation*, F.U.T. Akure, November 7th - 9th 2012, pp 155-159.

Brian, P. M., Robert B. R. and Gelson .T. (2012). Non-Timber Forest Products and Rural Poverty Alleviation in Zambia Working Paper No. 62.

Food and Agriculture Organization (FAO) (2004). *Global forest resources assessment update 2005 Terms and definitions (Final version)*, Food and Agriculture Organization of the United Nations, Rome. Available at: www.fao.org/docrep

Offiong, E.E and Ita, P.B (2013). Non Timber Products for Food Security and Development in Nigeria. *Journal of Social sciences and Humanities.* 3(1):159

Ogundele F.O, Utin E.A, Iwara A.I., Njar .,G.N.,and Deckor T.N(2012): An Assessment of Non-Timber Forest Products Utilization on Rural Livelihoods in Ini Local Government Area of Awka Ibom State, Nigeria, *Journal of biodiversity and environmental science*, Vol 2, No 8 p.1-13

Osalusi C.S, Usman J.M, and Pitan O.O (2011): Profitability of Non-Timber Forest Products in Rainforest Area of Ondo State, Nigeria. *Journal of Forestry Research and Management Vol.8, 2011. Pp27-35*

Shackleton, S.E. & Shackleton, C.M. (2004). The *Pterocarpus angolensis* DC. Based woodcraft industry in the Bushbuckridge district, South Africa. In: Sunderland, T. & Ndoye, O. (eds). *Forest products,* , Bogor. pp. 203-228.

Assessment of Community Participation as a Tool for Forest Law Enforcement in the Rainforest Ecological Zone, Cross River State, Nigeria

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ABSTRACT

The study assesses the potentials of community participation (CP) techniques with a view to strengthening forest law enforcement and sustaining the collaboration of government and forest stakeholders in sustainable forest management. The specific objectives were to determine the level of involvement of stakeholders in community participation in forest management and to investigate the varieties of incentive needed by stakeholders for effective forest law enforcement. The method used for the study was socio-economic survey among the stakeholders in Rainforest Ecological Zone in Cross River State (CRS), Nigeria to gather data through observations and conducting a survey questionnaire. A total of 300 stakeholders responded; 198 (66%) were involved in community participation. Analysis was done using chi-square which was significant (χ^2 =294.25) at P <0.0005. Incentives needed for effective forest law enforcement for community participation in the Rainforest Ecological Zone of CRS revealed that Soft Loan (SL) had the most significant variable with odd-ratio of 16324.14. This was followed by Community Involvement in Decision Making (CIDM), Technical Assistance (TA), Working Tools and Infrastructure (WTI) and Training and Capacity Building (TCB) with odd-ratios of 562, 131.20, 18.82 and 8.12, respectively. The higher the value of odd-ratios, the more likelihood the incentives contributed to effective forest law enforcement of community-based forest management in rainforest ecological zone in Cross River State. The regression parameters in the model were statistically significant. CP has been fairly used as a tool for enforcing forest laws in the Rainforest Ecological Zone, Cross River State. It is recommended that the State's Legislative Assembly should of necessity debate and pass the bills on incentives such as Soft Loan (SL); Community Involvement in Decision Making (CIDM); Technical Assistance (TA); Working Tools and Infrastructure (WTI) and Training and Capacity Building (TCB) that influence Effective Forest Law Enforcement (EFLE) as a tool for Community-Based Forest Management in the rainforest ecological zone of Cross River State.

Keywords: Ecological zone, incentives, forest law, community participation

INTRODUCTION

Forests account for about one-third of the total land area of the world (FAO, 2010). Throughout human history, forests have been essential for human well-being and currently contribute to the livelihoods of an estimated 1.6 billion people worldwide (World Bank, 2004). Community participation in the rainforest ecological zone is a concept of developing partnerships between fringe forest users and the Government who are in custody of the forest estate. The key characteristics of CP, therefore, include a meaningful community involvement in, or control of, decision-making about forest management and retention of benefits of forests use and management within the community (Onibon, 2000; Egan *et al.*, 2002). Community participation nowadays is perceived as critical in controlling illegal forest activities in developing region since local people here have greater stakes on forests than any other region on earth, where they are somehow responsible for the deforestation and forest degradation and are also the most vulnerable to its consequences. Law is an ordinance of reasons for the common good promulgated and authenticated by those who have competent and legitimate authority in the community and occupying positions of power and influence (Alhott, 1980). Laws are promulgated to shape societal behaviour in conformity with the goals identified by the government of the day. It is used to promote peace and order. Where there is no law, there is no offence. With particular regard to forestry, forest laws are essentially instituted to protect forestry in terms of resource, enterprise and economic development. Law is generally a sacrosanct derivative of the constitution of a state/country. However, forest laws are specifically instituted to protect forests against all offences. Enforcement refers to the act of enforcing and also using compulsion. It is a force applied to make sure that the law works.

Forest law enforcement therefore, refers to the various measures to ensure compliance with rules and regulations that are put in place to promote sustainable management of forests and these measures include prevention, detection and suppression (Winston, 2007). It is also defined as protection of forest encompassing 'all restrictions and operations directed primarily to the preservation or replacement of a forest'. These laws are passed by a legislative body, be it under a military government or under a civilian democracy. Forestry law has also introduced some measures to curtail the commission of forestry offences. As a preventive measure to curtail the commission of forestry offences, it is lawful to stop, open, enter and search any forest-product-laden vehicle, boat or craft for the purpose of inspection of the produce (Akhihiero, 2006). Forest law enforcement and governance (FLEG) has emerged as a major policy response by international agencies and national governments seeking to promote good forest management. Specifically, forest governance is associated with the government agencies where official authority and power is located including ministries of forestry, agriculture, environment and other regulatory agencies. It is associated with the laws, regulations and policies that govern the activities of these agencies. It is also affected by how these agencies engage with other institutions of the civil society, the private sector and private individuals (World Resources Institute, 2003). In Nigeria, the forest laws and regulation have always existed with state forestry services. These laws have not been revised to suit contemporary conditions. There is need for a review of the existing Forest Laws in the 36 states of Nigeria to take care of grey areas. The forestry laws of the 36 states in Nigeria were derived from the forestry laws of the former four regions with specific modifications according to local needs and circumstances. The laws are outdated and do not represent the realities on ground (Adeyoju, 1989). Also, there is no national forestry law to moderate the state laws. Forestry has suffered progressive neglect; the National Assembly passed the National Forest Policy in 2006, with no laws backing the policies. Owing to the Federal character of the Nigerian constitution, the forest estates are administered by states in which they are sited. In all the edicts, the practice of professional forestry is restricted to the forest reserves that make up the forest estates. Salient and coherent information on stakeholders' involvement in community participation in rainforest management in Cross River State of Nigeria has been extremely limited. However, a notable but relatively narrow exception is a strong State Forestry department and /or Forestry Commission involvement in community participation. The purpose of stimulating and contributing the rightful quota of stakeholders to community participation in rainforest management in Cross River State relies on provision of incentives to rural dwellers within and around the forest reserves. However, majority of these rural dwellers now have little or no motivation to join hands with the State Forestry to adequately enforce forest law within and around the forest reserves. It is very important for the rural dwellers within and around the forest reserves to have access to incentives so as to sustain their commitment to the sustained defined forestry objectives. The study investigated the level of involvement of stakeholders' in community participation in rainforest management; and variety of incentives needed by stakeholders for effective forest law enforcement.

In view of the role of community participation in forest resources management, this study, therefore takes a critical look at the evaluation of the potentials of community participation in rainforest ecological zone with a view to strengthening forest law enforcement and sustaining the collaboration of government and forest stakeholders in sustainable forest management.

METHODOLOGY

Study Area

The study was conducted in the rainforest ecological zone of Cross River State of South-South Nigeria Cross River State is located within the tropical rain forest of Nigeria. It lies between Latitude 4^0 30^1 and 7^0 00^1 and Longitude 7^0 30^1 and 9^0 50^1 East of the Greenwich Meridian. It shares common boundaries with the Republic of Cameroon in the East, Benue State in the North, Ebonyi and Abia States in the West, Akwa Ibom State in the South West and the Atlantic Ocean in the South (Figures 1 and 2). Cross River State has a total landmass of about 9800km.Arising from the location; the state enjoys a tropical climate with the Obudu plateau at an altitude of 1595.79 metres above sea level and also with a temperate climate. The state records a heavy rainfall during the wet season (April- November) and the annual rainfall varies from 1800 to 4000mm; the annual temperature ranges from 10 to 32 ^{0}C. The rainfall decreases from the south (3500mm) on the coastal region to 1,500m on the northern part of the state. The state is rich in Agricultural products. The state has 17 forest reserves with a total area of about 2974km.Nine (9) communities in Cross River State had also donated 5493 hectares of community forest land to the Forestry Commission.(Annual Report,2007).

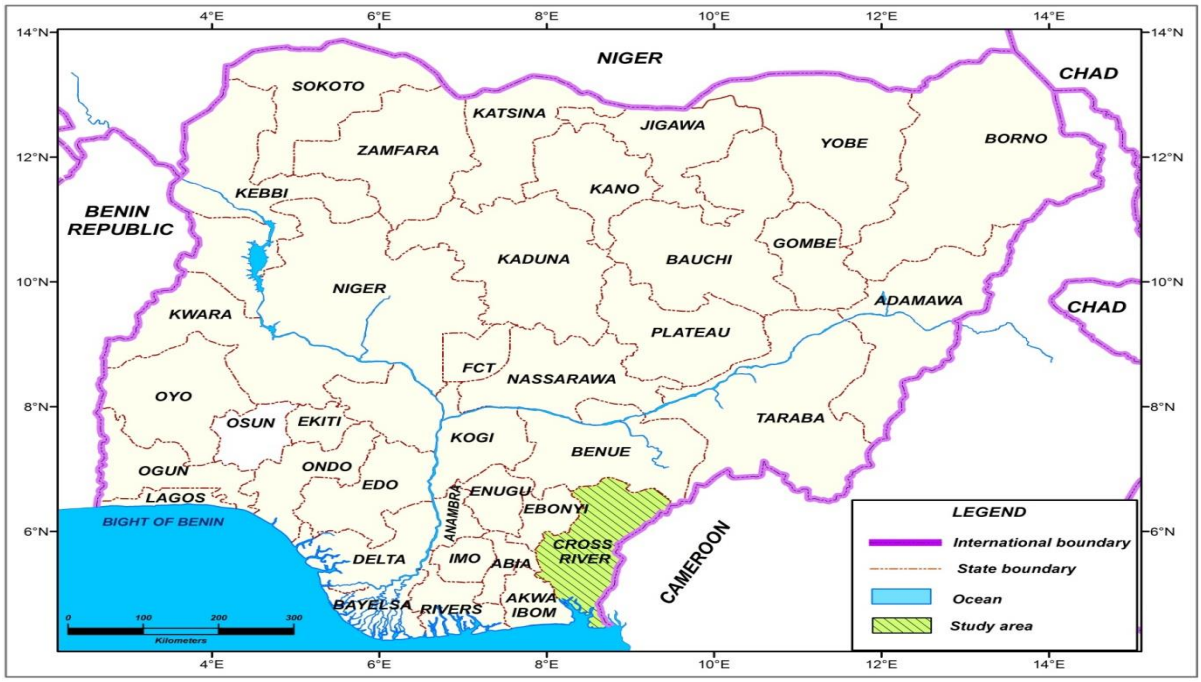


Figure 1: Map of Nigeria showing Cross River State

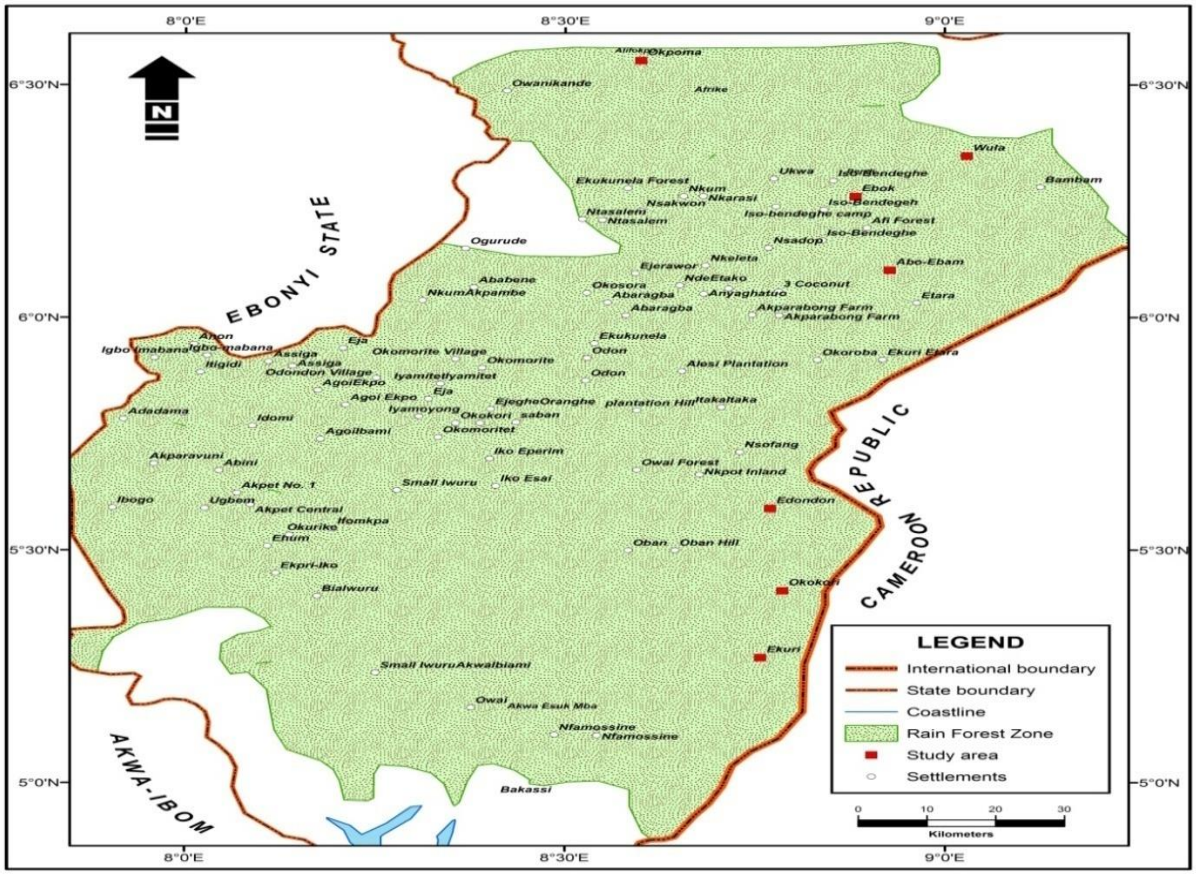


Figure 2: Rainforest Ecological Zone

METHODS AND DATA COLLECTION

Study Design

The study design employed was observational and socio-economic in nature. The sample frame for the study involved a field survey which entailed detailed appraisal of two specific objectives. These objectives were carried out through the use of structured questionnaires to collect data from relevant stakeholders such timber contractors/loggers, migrants, farmers and rural dwellers living within and around the forest reserves and representatives of NGOs in the study locations on the level of involvement of stakeholders in community participation in forest management and to investigate the variety of incentives that would enhance proper participation as a tool for forest law enforcement in the study area. The study was carried out between December, 2014 and February, 2015. Two Local Government Areas namely Boki and Akamkpa were selected and six communities namely Wula, Ebok, Abo-ebam, Ekuri, Edondon and Okokori were randomly selected in the two local government areas for field data collection (Table 1). Diaw *et al.* (2002) was used for sampling intensity. Simple percentage was used to analyse the level of involvement of stakeholders in community participation while Logit regression was used to analyse the variety of incentives that would enhance proper participation of community as a tool for forest law enforcement in the study area.

DATA ANALYSIS

Descriptive and logistic binary models were used to analyse the data collected for the study.
The binary logistic models are very useful in situations where the dependent variable is binary in nature. This implies that they can have only two possible values. The models, therefore, describes the relationship between one or more continuous independent variable(s) to the binary dependent variable. The two common binary models are the logistic model and the probit. The logistic model is particularly preferred because of the unique information it provides. The distinct information provided by the logistic model is the odd ratio of it occurring in another group. (Deeks, 1996; Bland and Altman, 2002).The logistic model also provides information on the consequences of one variable on the other. Hence, it will clearly indicate the variable(s) i.e. incentives for CP that mostly contribute to the forest law enforcement.
The logistic model of a response *p* between 0 and 1 is given as:

$$Log_{it(p)} = \log(p/1\text{-}p) = \log(p) - \log(1\text{-}p)$$

The simplest form of logistic model is expressed as: $Log_{it}(p_i) = a + bx_i$
Where p_i = vector of predictor or independent variables, p_i = probability of an effective incentives for CF on Forest Law Enforcement in the Cross River State, a and b = regression parameters.
In binary choice models, the two possible results were assigned values of 1 or 0. In this study, respondents who said yes to incentives for Community Participation (CP) that influences Forest Law Enforcement were assigned a value of 1 and respondents that said no to incentives for CP that influences Forest Law Enforcement were assigned a value of 0. The parameter estimation for this study was done using the Quasi-Newton method. Emphasis was placed on keeping the model as simple as possible and selecting combinations of independent variables which make practical sense.

Table 1: Distribution of respondents of communities in the Rainforest Ecological Zone in Cross River State

Ecological Zone	Local Government Areas	Communities	Number of Questionnaire Administered	Number of Questionnaire Returned
Rainforest	Boki	Wu la	50	50
		Ebok	50	50
		Abo-ebam	50	50
	Akamkpa	Ekuri	50	50
		Edondon	50	50
		Okokori	50	50
TOTAL			**300**	**300**

Source: Field Survey, 2014/2015

RESULTS

Level of involvement of stakeholders in community participation

The respondents' view on their level of involvement in Community Forest Management participation within and around the reserves indicated that 198 (66%) were involved and 102 respondents (34%) showed those that were not involved in Rainforest Ecological Zone in Cross River State. A total of 192 respondents (64.0%) indicated their level of satisfaction in the management of the forest reserves and 108 (36.0%) were not satisfied with the management of the forest reserves. The findings showed that 212 (70.7%) respondents affirmed that forestry service was enforcing the legal measures for protection of forest reserves while 88(29.3%) respondents did not agree.

Logistic models on incentives for community participation as a tool for forest law enforcement in the rainforest ecological zone of Cross River State

In this study, the binary logistic regression analysis was used to investigate the incentives that influence Effective of Forest Law Enforcement in the Rainforest Ecological Zone in Cross River State. The variety and of quality incentives needed by stakeholders for effective Forest Law Enforcement investigated were Community Involvement in Decision Making (*CIDM*), Financial Empowerment (*FE)*, Working Tools and Infrastructure (*WTI*), Training and Capacity Building (*TCB*), Soft Loan (*SL*), Policing and Security (*PS*), State Financial Assistance for Participation (*SFAP*), International Financial Assistance (*IFA*), Technical Assistance (*TA*) and Benefit Sharing for Stakeholders (*BSS*). Preliminary investigation involved fitting all these incentives together and then backward elimination was done to obtain the best subset models. The resulting models were evaluated using the chi-square goodness-of-fit statistics (Bruhn *et al*. 1991). The final loss on accuracy was computed using maximum likelihood estimation method and odds ratio (Deeks, 1996; Davies *et al.,* 1998).

Rainforest Ecological Zone

$$EFLE_{(\text{Rainforest})} = 2.71E{+}01 + 1.72CIDM - 72.41FE + 2.93WTI + 2.09TCB + 9.70SL - 2.05PS + 0.07SFAP - 35.66IFA + 4.88TA - 1.15BSS \quad \text{Equation 1}$$

- N =300, Final Loss = 60.15, Chi square (df,10) =294.25, p=0.0000
- Odd ratio (Unit change): Constant (6.10E+11); *CIDM*(562); *FE*(0.00); *WTI*(18.82); *TCB*(8.12); *SL*(16324.14); *PS*(0.13); *SFAP* (1.08); *IFA*(0.00); *TA*(131.20); *BSS*(0.32)

Model 1 in equation 1 presented above for Rainforest zone gave overall significant fit to the data judging from Chi-square value that is significant at p<0.0005. There was sufficient evidence that the estimated coefficients were not zero for independent variables. This implies that the regression parameters in the model were statistically significant. However, the higher the value of odd-ratios, the more likelihood the variable contributes to Effective Forest Law Enforcement as a tool for Community Participation(CP) in the Rainforest Zone in Cross River State. Soft Loan (*SL*) was the most significant variable with odd-ratio of 16324.14 followed by Community Involvement in Decision Making (*CIDM*), Technical Assistance (*TA*), Working Tools and Infrastructure (*WTI*) and Training and Capacity Building (TCB) with odd-ratios of 562, 131.20, 18.82 and 8.12, respectively (Table 2).

Table 2: Logistic binary nature of effective forest law enforcement in the Rainforest Zone, Cross River State

Dependent Variable (*EFLE*): Effective Forest Law Enforcement (Presence =1; Absence=0)		
Independent Variables	Coefficient	Odds-ratio
Whether presence of *CIDM* will make Forest Law Enforcement effective for CP	1.72	562*
Whether presence of *FE* will make Forest Law Enforcement effective for CP	-72.41	0.00
Whether presence of *WTI* will make Forest Law Enforcement effective for CP	2.93	18.82*
Whether presence of *TCB* will make Forest Law Enforcement effective for CP	2.09	8.12*
Whether presence of *SL* will make Forest Law Enforcement effective for CP	9.70	16324.14*
Whether presence of *PS* will make Forest Law Enforcement effective for CP	-2.05	0.13
Whether presence of *SFAP* will make Forest Law Enforcement effective for CP	0.07	1.08
Whether presence of *IFA* will make Forest Law Enforcement effective for CP	-35.66	0.00
Whether presence of *TA* will make Forest Law Enforcement effective for CP	4.88	131.20*
Whether presence of *BSS* will make Forest Law Enforcement effective for CP	-1.15	0.32
Model χ^2 (df=10) = 294.25*		

* p<0.0005

DISCUSSION

The respondents' view on their level of involvement in Community participation within and around the reserves in the study communities was predicated on the management of forest resources by local communities which has since been gaining credence over the years; owing to the need for inclusion of rural dwellers in the management of resources that are found closest to them (FAO, 2000). The higher the value of odd-ratios, the more likelihood the incentives that contribute to Effective Forest Law Enforcement as a tool for Community Forest Management in the Rainforest Zone in Cross River State.

CONCLUSION AND RECOMMENDATIONS

Conclusion

Community participation has been fairly used as a tool for enforcing forest laws in Rainforest Ecological Zone in Cross River State. However, the Forestry Commission has been feeble in discharging its statutory functions. There is an urgent need for the State Forestry Commission in Cross River State to formulate forestry programmes that will involve Community Involvement in Decision Making by all stakeholders for more participatory community forestry.

Recommendations

- All stakeholders including local communities must be actively involved in forest policy formulation and monitoring of development of activities. This would ensure sustainable forest management in Cross River State.
- The State Legislative Assembly should of necessity debate and pass the bills on incentives like Community Involvement in Decision Making *(CIDM*); Training and Capacity Building (*TCB*); Financial Empowerment (*FE);* and Soft Loan (*SL*) for Effective Forest Law Enforcement (*EFLE*) as a tool for Community participation in Forest Management in Rainforest Ecological Zone of Cross River State

REFERENCES

Adeyoju, S. K. 1989. A note book on Forest Resources Policy, Law and Administration. Department of Forest Resources Management, University of Ibadan. In: Oni, T. M., 2008. "Stakeholders' Perceived Compliance with Forestry-Related Protection Laws in Southwestern Nigeria". Unpublished Ph.D Thesis. 330 pp.

Akhihiero, P.A. 2006. Application of the Forestry laws in forestry management. A Legal workshop for stakeholders in the forest industry in Edo state of Nigeria Organised by the Edo State Ministry of Agriculture and Natural Resources on the 9th February, 2006.

Alhott, A. 1980. The Limits of Law. London, Butterworths. 18pp.

Bland, J.M. and Altman, D.G. 2000. ''The odds ratio''. *British Medical Journal* 230, 1468.

CRSFC (Cross River State Forestry Commission) 2007: Cross River State ForestryAnnual Report.;Pp.2–4.

Deeks, J. (1996): Swots corner: what is an odds ratio? Bandolier,3 (3), Issue 25, 6-7.Democracy, Governance and Human Rights, Paper No. 8, UNRISD, 2002.

Diaw, K, Blay, D. and Adu-Anning, C. 2002. Socio-economic survey of forest fringe communities: Krokosua Hills Forest Reserve. A report submitted to the Forestry Commission of Ghana. 86pp.

Egan, B., Ambus, L., and Woodsworth, A. 2002.Community Forestry, Concept and Characteristics, a background paper prepared for BC Community Forestry Forum, Victoria, British Columbia.

FAO 2010. Developing Effective Forest Policy: A guide-FAO Forestry Paper 161. Food and Agricultural Organisation of the United Nations, Rome, Italy. P.80

FAO (2000): Forest resources assessment 1990, tropical countries, FAO forestry paper 112, FAO Rome 61pp.

Onibon, A. 2002: From Participation to irresponsibilities. *Forest, Trees and People Newsletter.*No.42, June 2000 Pp.4-10.

Winston, M. 2007. A paper prepared for the East African Community –Led regional process in the framework of the Ministerial Declaration, Yaounde, Cameroon, October, 16, 2003 on the African Forest Law Enforcement and Governance (AFLEG). Pp.64

World Resources Institute 2003: World Resources 2002-2004: Decisions for the Earth: Balance, Voice, and power. Washington, D.C.WRI, P. 329

Declining Paper Industry: A Threat to Nigeria Economy and the Way Forward

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ABSTRACT

Nigeria paper industry has not reached the optimum performance level expected of it by planners despite the huge money spent on the establishment of pulp and paper mills in the country before it finally stop production in 1994 due to the high dependence on foreign inputs. This paper examines the problems militating against pulp and paper production in Nigeria and highlights the pathway for promoting optimal pulp and paper capacities locally. Commonly used tree species for pulp and paper production like Gmelina arborea, Pinus caribaea, etc. are threatened due to high rate of deforestation and increasing demand of their wood for other economic purposes. Hence, none of the three primary pulp and paper mills established in the country by government within 1960s to 1970s performed optimally except The Nigerian Paper Mill, Jebba in the 1980's as pulp and paper importation reduced drastically as a result of high capacity utilization in the mills. In 1985 and 1986, capacity utilization in Nigerian Paper Mill was 62.3% in 1960's and 66.17% in the 1960's. In 1996, The Nigeria Newsprint Manufacturing Company (NNMC), Oku Iboku also stopped production leading to complete dependence on importation of paper and paper products. In 2006, the mills were privatized, and, currently more than 500 billion naira is expended on importation of paper products annually. The only and urgent remedy is to put in place machinery for massive sustainable wood production. Likewise, the use of indigenous wood species and agricultural residues should be encouraged for long fiber pulp production. Efforts should further be made for a stable power supply from national grid to ensure the sustainability of industrial growth most especially in the pulp and paper industries.

Keywords: Forest product, pulp, paper, newsprint, manufacturing, industry

INTRODUCTION

Pulp and paper products have been the largest forest products imported into Nigeria. For many years, the need for the development of pulp and paper capacities in developing countries were of limited interest as a result of the stability experienced in the global pulp and paper market (Picornell, 1984). However, as the global economy began to expand in the late 1950's through the 1970's and the market for pulp, paper and paperboard began to increase, developing countries began to engage in pulp and paper manufacturing. This development was encouraged by four main factors. These include the need to make use of available raw materials and reduce foreign exchange expenditure; to protect local consumers from the high import prices; to develop local industry and provide employment; and, to promote national industrial development aspirations (Picornell, 1984).

However, the disadvantages of establishing pulp and paper mills in developing countries were observed to be many. Among these are relatively small markets, low range of products output, high dependence on imported inputs resulting in higher cost of operation compared to similar mills in developed countries, dependence on foreign management and technical personnel; high cost of energy and imported chemicals, coupled with low exchange value of domestic currencies concerns (Ogunwusi 2011).

History of Pulp and Paper Products and Production in Nigeria

The pulp and paper industry in Nigeria was one of the major industries that performed well in the 70-80's before the oil boom era as self-sufficiency in paper production was one of the major cardinal objectives of the Nigerian government. This was evidenced by the local establishment of three integrated pulp and paper mills between 1969 and 1976. Two of the mills: the Nigeria Paper Mill, Jebba (NPM) and the Nigeria Newsprint Manufacturing Company (NNMC), Oku Iboku, performed optimally and paper importation drastically reduced in the 1980's (CBN, 1994). The Nigeria Paper Mill, Jebba's actual production in 1985 was 40, 480Mt increased to 42,960Mt in 1986, representing 62.3% and 66.17% capacity utilization respectively. This pattern of capacity utilization was also experienced at the Nigeria Newsprint Manufacturing Company, (NNMC), Oku- Iboku about the same period. The volume of production at NNMC rose from 28,927Mt in 1989, and to 37,581Mt in 1990 (CBN, 1990,; CBN,1992). Due to establishment of the NNMC, importation of newsprints reduced drastically from 17.5% in 1986 to 12.5% in 1987 respectively and completely stopped in

1988 (CBN, 1994). However, the downturn in the economy in the 1990's revealed the structural weakness of government led industrialization strategy. The mills which were mostly owned by the Federal Government depended extensively on foreign inputs inform of long fiber pulp, management and technical expertise and spare parts. Thus, the integrated mills became convulsed in the 1990's and capacity utilization completely stopped. Capacity utilization at the Nigeria Paper Mill became as low as 2.5% in the early 1990's until the mill stopped production in 1996 (RMRDC, 2009).

Iwopin Pulp and Paper Company, being the third pulp and paper mill company was also established in 1976 to produce fine writing, printing and cultural papers. It was abandoned in 1983, when the mill installation was at about 85% completion, and up till the time it was shut down in 1998, the mill never produced up to 5% of its installed capacity (Osadare, 1997; RMRDC, 2009). In line with the privatization agenda of the Federal Government, the primary pulp and paper mills were privatized in 2006. This situation has seriously affected the pulp and paper industry in Nigeria.

Table 1: Demand and Supply statistics on some of the major raw materials required in the pulp and paper sector in 2005

S/N	Raw Materials	National Production	National Demand	Supply gap	Supply gap (%)
1.	Long Fiber Pulp (BDMT)	0	85,668.1	85,668.1	100
2.	Short Fiber Pulp (BDMT)	0	280,000.0	280,000.0	100
3.	Waste Paper	74,000.0	100,000.0	26,000.0	26
4.	Kraft Paper	0	80,000.0	80,000.0	100
5.	Fluiting paper	0	20,000.0	20,000.0	100
6.	Newsprint	0	250,000.0	250,000.0	100
7.	Sodium sulphate (tones)	0	2,600	2,600	100
8.	Sodium sulphate (tones)	0	6,000	180,000	100
9.	Soda ash (tones)	0	55	55	100
10.	Sodium Hydroxide	0	144,260	144,260	100

Source: RMRDC (2009)

Table 2: Summary of Capacity Utilization in the Pulp, Paper, Paper Products, Printing and Publishing Sector (2003-2006)

S/N	Sub-Sector		Installed Capacity (Mt)	Capacity Utilization (%)				Average Capacity Utilization (%)
				Year				
				2003	2004	2005	2006	
1.	Primary Paper	(Fiber sources)	1,169,145.00	4.92	5.98	6.33	6.84	6.38
2.	Primary Paper	(Chemicals)	105,262,517.00	0.00	0.00	0.00	0.00	0.00
3.	Stationery, (Paper)	Light/Heavy Packaging	3,467,400.00	68.44	75.87	84.81	88.07	82.92
4.	Stationery, (Boards)	Light/Heavy Packaging	463,410.00	79.62	85.06	85.71	87.61	84.53
5.	Stationery, (Chemicals)	Light/Heavy Packaging	571,093.00	76.54	80.24	85.71	87.61	84.53
6.	Stationery, (Miscellaneous)	Light/Heavy Packaging	10,203,418.00	63.64	59.67	60.61	62.64	60.97
7.	Printing and Publishing (Paper)		42,903.00	17.64	19.24	20.68	22.222	2.71
8.	Printing and Publishing (Boards)		499,271.00	58.81	61.18	63.16	65.88	63.41
9.	Printing and Publishing (Chemicals)		20,808.00	46.18	46.74	47.49	47.96	47.40
10.	Printing and Publishing (Miscellaneous)		25,573.00	88.98	89.18	89.40	89.83	89.47
Total	**Annual Capacity Utilization (%)**							**54.18**

Source: RMRDC (2009)

Demand and Supply statistics on some of the major raw materials and capacity utilization in the Pulp, Paper Products, Printing and Publishing Sector

The supply gap for long fiber pulp, kraft paper, newsprint, bank paper, etc. were met through importation in 2005 (RMRDC, 2009) (Table 1). Also, the pulp and paper capacity utilization in the primary pulp and paper sub-sector (fiber source) increased from 4.92% in 2003 to 6.33% in 2005 and to 6.84% in 2006, resulting in average capacity utilization of 6.38% in the primary pulp and paper

subsector (Table 2). The very low capacity utilization in this sub-sector is attributable to status of the three primary pulp and paper mills as the activity in the subsector was only sustained by waste paper recycling (RMRDC, 2009). Local production capacity of chemical raw materials remained nil throughout the period (between 2003and 2006). The, capacity utilization of the stationary (paper) in 2003 was 68.44%, this increased to 75.87% in 2004, 84.81% in 2005 and to 88.07% in 2006. While, the capacity utilization of stationary (board) in 2003 was 79.62%, this increased to 85.06% in 2004, 85.57% in 2005 and 87.39% in 2006. The overall capacity utilization in the entire sector was 54.18% (RMRDC, 2009) (Table 2). The high capacity utilization recorded by the printing, stationary and other subsectors apart from primary paper manufacturers was mainly due to high exchange rate expended on paper imports. This became important in view of the need to satisfy the requirements of the Universal Basic Education as promulgated by government coupled with increase in publicity generated by political activities in the country (RMRDC, 2009). It was observed that, apart from the 26% of waste paper raw material which was sourced locally for production of tissue papers, the demands for the rest 74% other raw materials (paper, chemicals, etc.) were largely met through importation (RMRDC, 2009). Same trend is still the order of the day in the pulp and paper industry in Nigeria.

Challenges Faced By Nigeria Paper Mills

The plight of the stationary, light packaging and the printing and publishing sub-sectors of the pulp and paper industry have not been radically different from that of primary paper manufacturing (Alao, 2005). Today, just as in the 70's, 80's and 90's the challenges of the pulp and paper industry includes:

i. **Problem of high foreign exchange:** High foreign exchange level caused by continuous depreciation of the naira and collapsed infrastructure.
ii. **Poor power supply:** Poor power supply due to skyrocketing prices of diesel thereby increased input of paper production.
iii. **Poor finance:** Pulp and paper mills in Nigeria suffered gross underfunding. Government often time do not meet their budget estimation and whenever fund are released, they are often late in coming. (Alao 2005)
iv. **Inadequate manpower:** Like in all cadres, there was generally shortage of manpower in Nigeria paper mills (vocational, technical and professionals) (Alao, 2005). The government should put in place deliberate effort to recruit and/or to train people to fill these gaps.
v. **Inadequate or obsolete equipment:** Alao, (2005) has shown that the state of forest services lack the necessary equipment and tools and Sotonde (2000) also noted that the paper mills in Nigeria also lack the necessary equipment and tools to meet contemporary development challenges.
vi. **Inadequate research efforts:** Inadequate research efforts were not done into conversion and utilization of pulp and paper and mills development in Nigeria.
vii. **Poor policy and policy reversal:** sometimes, there are difficulties in understanding the policy statement because of non-clarity as they affect pulp and paper industry in Nigeria (Alao and Egbewole, 2010).
viii. **Problem of over dependent on importation of pulp and paper product:** The integrated pulp and paper mills in Nigeria depend overwhelmingly on imported long fiber pulp.

Disadvantages of Over Dependent on Importation of Pulp and Paper Product

The integrated pulp and paper mills in Nigeria depend overwhelmingly on imported long fiber pulp. The forests in Nigeria consists predominantly mixed tropical hardwood species whose fiber lengths are short varying from 0.8m to 1.6mm. Dinwoodie (1965) reported that, fiber length is an important factor influencing strength development in paper. Casey (1980) also noted that the differences observed in comparing the properties of paper from different fiber sources are mainly due to the influence of fiber characteristics. According to Raw Material Research and Development Council RMRDC (2009), impact on this negative trend in the pulp and paper industry more sufficiently that the sector was losing 400bn yearly to paper products importation. The amount which could be saved over the major operating form is revived. Estimate of import of finished products in the sector amount is 400bn annually and at the same time create over 200,000 job opportunity for young Nigerians. According to CBN (1992), the printing and publishing sub-sectors experienced a general increase in the production of document, while booklet type products relating from 1999 to 2004. This is rather a good performance of the printing and publishing subsector; CBN said was a direct consequence of the high level of political activities in the country and the exploitation in student turnover given zero capacity utilization in the primary paper manufacturing sub-sector. This performance was sustained through importation of critical raw material which has all along been described as unhealthy for the economy

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The Way Forward; Strategies for Maximizing Pulp and Paper Production

Without any doubt, there is need for production of optimal quantity and quality of pulp and paper products. This has over the year of inactive operation of the paper mill been recognized locally. Some of the approaches that may be instituted sequel to the privatization of the three integrated pulp and paper mills are:

i. Exploring the optimal performance of *Pinus Species* and other potential long fiber species

One of the strategic plans of the Nigerian government for the development of the paper industry was to promote plantation establishment of *Pinus species* for long fiber pulp production. In view of this, seeds were imported and established in plantations in various locations within the savanna and forest ecologies in Nigeria (Ojo, 1971). While some successes were recorded at the early stage of the project, the exercise later turned out to be a failure (Momoh, 1970). One of the major causes of the failure was the inability of the micorrhiza imported to become established in the field (Momoh, 1971). The micorrhiza functions as an absorbing organ for the plant and failure of pine plantations and nurseries were attributed to the lack of development of the micorrhiza association (Jackson, 1971). The failure of the miccorhiza to become established was associated with high temperature (Momoh, 1970). According to Jackson (1971), in the savanna region of Nigeria, pines have to be initially inoculated with micorrhiza if satisfactory results were to be obtained. Despite this and several other methods that were tried, the project did not record adequate success. Thus, Madu (1971) summarized that the failure of the project was due to lack of suitable miccorhiza in Nigerian soils. As a result, despite the efforts of pioneer foresters in Nigeria, *Pinus species* can only be found on experimental plots in locations such as Afaka in Kaduna State and Miango in Jos, Ijaye Forest Reserve in Oyo State and in a number of other isolated areas (RMRDC, 1991).

ii. Utilization of Kenaf as a Raw Material for Long Fiber Pulp Production

Kenaf is currently being explored in most developed and developing countries as a viable raw material for pulp and paper production. In Nigeria, efforts have been made to promote kenaf utilization in the pulp and paper industry. Udohitinah and Oluwadare (2001) reported the mean fiber length of locally grown kenaf to be 2.90mm while the fiber diameter was reported as 28.16μm; lumen width, 6.08μm; and cell wall thickness; 11.04μm respectively. While, in Malaysia; due to the potential commercial value of kenaf, the government allocated RM 12 million for research and development of kenaf based industry under the 9th Malaysian development plan (2006-2010) (MohdEdecrrozey *et al*, 2007). It had been observed that, the average fiber length, diameter, lumen width and cell wall thickness of the kenaf sample compared with the fiber dimensions of kenaf varieties reported by Ververis *et al,* (2009), and Nkaa *et al,* (2004). It was also observed to be comparable to the range of 2.7mm to 4.6mm for softwood tracheid (Ates *et al,* 2008). Consequently, Uddohitinah and Osadere (2001) opined that kenaf fiber could go a long way in alleviating the problems posed by a shortage of long fiber pulp to Nigeria pulp and paper mills.

iii. Development and Utilization of Long Fiber Pulp from *Sterculia setigera*

One of the major indigenous raw materials reported locally to have long fiber characteristics is *Sterculia setigera.* Oluwadare and Egbewole, (2008) reported the fiber length to be 2.41mm. As a result of its long fiber length value, *S. setigera* can be regarded as a long fiber wood species in accordance with the classification of Bublitz (1980). Consequently, *S. setigera* may produce pulp with properties reminiscent to those of imported long fiber pulp. Its mean wood density was 249kg/m^3 (Oginwusi, 2002). Although, this density value is within the acceptable range for pulp and paper production, it is considered low and may lead to low pulp yield. The low density may place *S. setigera* at a disadvantage as pulp wood raw materials when the economy of optimal digester packing is considered (Casey, 1980).

iv. Utilization of *Sterculia oblonga* for Long Fiber Pulp Production

Sterculia Oblonga is also one of the indigenous wood species that has been reported to have long fiber length. Osadere (1996) in a preliminary work carried out on *Sterculia Oblonga* from Nigeria showed the fiber characteristics of the plant species to be as presented in Table 3. The average fiber length of the wood species is 2.07mm which is higher than in most hardwood species. The alcohol benzene solubility is 3.6% and the wood density was 260kg/m^3 (Table 3). The strength properties of unbleached kraft paper at K-NO 10 were also reported by Osadere (1996) to be within acceptable range when compared with commercial kraft paper at Nigeria Paper Mill. In the light of the above, the development of the Nigeria Pulp and Paper industry may be premised on long fiber raw materials sourcing from plantation grown *Sterculia oblonga*.

v. Bamboo Utilization for Pulp and Paper Production

Despite bamboo's ubiquity in some parts of Nigeria, little or no attention has been directed towards its development while bamboo is a popular raw material for pulp and paper making in countries such China, India and Malaysia. In recent study, Egbewole *et al,* (2016) indicated that bamboo is widely distributed in the south and middle belts regions of Nigeria. Despite this, bamboo utilization for pulp and paper production locally was inconsistent as it was dropped by the Nigeria Paper Mill, Jebba in 1980's as a result of silica deposition problems experienced by the mill. Ognwusi and Uwajeh (2009) reported that, the hot water solubility of the species ranged from 5.37% - 7.28%, the cold water solubility from 5.37% - 7.28% and the 1% caustic soda solubility from 19.6% - 25.1%. while, Ogunsile and Uwajeh, (2009) reported high cellulose contents which can lead to high pulp yield. They further reported high ligin contents suggesting high liquor consumption and long cooking cycle. However, the major problem of bamboo pulping is silica deposition (Andtbacha, 2005).

vi. Production of Pulp and Paper from Agricultural Residues

One of the major options available to countries with substantial agricultural produce is the production of paper from agricultural wastes. In India, three categories of pulp and paper mills are recognized. These are forest based mills; agro residues based mills and recycle fiber based mills (Schumacher and Sathaye, 1999). In 1992, forest based mills accounted for 49% of total raw materials input for paper, paperboard and newsprint production while agricultural residues and wastes paper accounted for 29% and 22% respectively (Sharma *et al*, 1988). In India, the consumption share of forest based materials has been declining overtime. The share of agricultural residues shows a steadily increasing trend since 1980 and it is expected to rise further in the future (Shumacher and Sathaye, 1999). The small paper mills set up in the early 1970's almost exclusively use agro raw materials/residues such as rice straws, wheat straw, and baggase which are relatively short cycle regenerative and abundant (King,1977); (Patel *et al*, 2011), Egbewole *et al* (2015) have recommended that developing countries like Nigeria should re-strategies and promote paper production processes that depend more on local raw materials to ensure the sustainability of the industry.

Source: Egbewole, *et al,* (2015)

Table 3: Comparative Assessment of Fibre Characteristics of Indigenous Woody and Fibrous Materials

S/ no	Non wood fibre	Fibre Length (mm)	Fibre Diameter (µm)	Lumen Width (µm)	Cell wall Thickness (µm)	Runkel Ratio 2 x CW/LW	Felting Coefficient FL/FD	Flexibility Ratio LW/FDx100 (%)
1	*Newbouldia laevis* (Egbewole *et al*, 2016)	2.31	19.54	14.57	2.48	0.31	119.30	74.70
2	*Bambusa vulgaris (*Egbewole *et al*, 2016)	2.88	14.80	9.55	2.52	0.55	112.55	64.62
3.	Moringa oleifera (Egbewole and Rotowa, 2016)	2.20	19.50	13.70	2.30	0.30	119.30	66.70
4	*Saccharun officinarum (*Egbewole, *et al* 2015)	1.62	20.78	13.26	7.52	0.57	76.73	63.81
5	*Thaumatococcus danielli* (Sotannde, 2000)	2.54	15.45	3.45	8.56	0.81	165.48	22
6	Bamboo (Pande, 1998)	2.7	15.0	-	-	-	180	-
7	Kenaf bastfibre (*Hibiscus cannabinus*) (Pande, 1998)	2.6	20.0	-	-	-	130	-
8	Jute (*Chorchorus capsularis*) (Pande, 1998)	2.5	20.0	-	-	-	135	-
9	*Abelmoschus esculentus* (okra stem) (Osadare and Udohitinah, 1993)	3.49	34.87	7.63	19.62	0.78	100	22
10	*Hibiscus cannabinus*(Kenaf) (Osadare and Udohitinah, 1993)	2.90	28.16	6.08	16.0	0.76	105.1	21
11	*Bombax buonopozense* (Gold coast Bombax)	3.83	29.85	5.80	18.25	0.68	114.1	20
12	*Musa sapentium* (bark)	4.48	30.16	4.34	21.44	0.42	149.1	15
13	*Steculiar oblonga* (yellow steculia bark) (Osadare 1997)	3.27	28.53	8.49	11.54	1.77	115.1	30
14	Reed (*Arundodonax*) (Pande, (1998)	1.8	20	-	-	-	90.0	-

CONCLUSION

The rate of paper consumption determines the level of illiteracy of a nation and the importance of paper and newsprint to national development cannot be overemphasized. However, Nigeria paper industry has not reached the optimum performance level expected of it by planners despite the huge money spent on the establishment of pulp and paper mills in the country before it finally stop production in 1996. Despite the problem associated with process of the Bureau for Public Enterprise (BPE) for the privatization of the integrated pulp and paper mills to be meaningful, it is imperative that efforts should be made to promote production of long fiber pulp locally. Any of the indigenous long fiber wood species discussed in this write up offers great potentials. As the total output from the integrated mills cannot satisfy local demand even if they are to function at maximum capacity, there is need to increase pulp and paper capacities locally by encouraging small scale paper mills to come on board. Small scale pulp and paper mills will provide opportunities for training managerial and technical personnel on several areas of pulp and paper production.

RECOMMENDATION

The under listed recommendations will help to attain a successful and sustainable wood production for pulp, paper and newsprint in Nigeria. They include among others:

i. Government should encourage private sector participation in paper production in the country. Private sector fund should be injected into the manufacturing of pulp and paper products.
ii To improve the participation in paper production in the country effort should be intensify at promoting self-sustenance in long fibre wood pulp production locally.
iii Government should show commitment to the provision of conducive operating environment by ensuing power sector reactivation and infrastructural resuscitation.
iv Government should provide an enabling environment that will attract private investor in forest plantation development and newsprint manufacture.
v Nigeria Paper Mill, Jebba (NPM), Nigerian Newsprint Industry, Oku Iboku and Iwopin Pulp and Paper Company (IPPC) should be resuscitated very fast. The Bureau for Public Enterprise (BPE) should prevail on the new owners of the mills to expedite action on it resuscitation so that pulp, paper and newsprint production can commence without further delay.
vi Pulp wood plantation, development of *Gmelina arborea, Pinus caribean* etc, should be reviewed and sustain by the Federal, State and Local Governments and other stake holders once the pulp and paper mills start production, government should protect it by restricting importation of pulp and paper products.
vii The development and utilization of local raw materials resources for use in pulp and paper production will help find a sustainable solution to the problem of the sector.

REFERENCES

Alao J. S. (2005): Capacity building modules in the Nigeria forest services. A PhD thesis submitted to the Forest Resources Management, University of Ibadan, Ibadan Nigeria. 301pp.

Alao, J.S. and Egbewole, Z.T. (2010): Sustainable wood production and the economics of newsprint in Nigeria. Practical issues in forestry and wildlife resource. pp317- 33.

Andtbacka, S. (2005): A. fiber line design for bamboo pulping. http://www.tapsa.co.za/archieve2/joournalpapers/bamboopulping.html retrieved June, 2012.

Ates, S.N., Akgui, M and Tozloglu, A.(2008): Characterization and evaluation of Paulownia elongate as a raw material for paper production. *African J. Biotechnol*. Vol (7), pp.4153-4158.

Bublitz, J.W. (1980): Pulpwood. In J.P Casey (Ed) Pulp Chemistry and Chemical Technology. Wiley Inter-science Publication. pp13-159

Casey, J.P (1980): Pulp and Paper Chemistry and Chemical Technology. Inter-science publishers.

Casey, J.P. (1980): Pulp and Paper chemistry and chemical technology. Third edition, Vol 1. Wiley Inter-science publication.

CBN (1990): Annual Report of the Central Bank of Nigeria, 1990

CBN (1992): Annual Report of the Central Bank of Nigeria, 1992

CBN (1994): Annual Report of the Central Bank of Nigeria, 1994

Dinwoodie, J.M. (1965): Relationship between fiber morphology and paper properties; A review of Literature. Tappi 48(8), pp440-447

Egbewole, Z.T., Rotowa O.J. and Suleiman A.I. (2016): Assessment of fibre quality of *Newbouldia laevis (p. beav)* for pulp and paper making. *Journal of Forest Science and Environment(JFSE).* A publication of Department of Forestry and Wildlife, Faculty of Agriculture, University of Maiduguri, Borno State, Nigeria. June, 2016.

Egbewole Z. T**.,** Rotowa O. J., Omoake, P. O. (2016): Evaluation of Fibre Quality Of *Bambusa vulgaris* (Bamboo) as a Raw Material for Pulp and Paper Production. *Production Agriculture and Technology Journal (PAT),*

online: www.patnsukjournal.net/currentissue. Publication of Faculty of Agriculture, Nasarawa State University, Keffi. *PAT December 20;* Vol. 11 (2), 188-202 ISSN: 0794-5213. pp 189- 202.

Egbewole Z. T**.** and Rotowa O. J (2016): Evaluation of fibre quality of *Moringa oleifera (Lam*) as raw material for pulp and paper production. *NSUK Journal of Science and Technology (NJST).* Publication of Nasarawa State University, Keffi. www.njst@nsuk.edu.ng Vol. 6(1), *2016.* ISSN 1597-5527. pp 42-49

Egbewole Z. T**.,** Omoake, P. O. and Rotowa O. J. (2015): Fibre Quality Assessment of *Saccharum officinarum* (Sugarcane) Bagasse as a Raw Material for Pulp and Paper Production. *NSUK Journal of Science and Technology (NJST).* Publication of Nasarawa State University, Keffi. www.njst@nsuk.edu.ng Vol. 5(2), *2015.* ISSN 1597-5527. pp 142-149.

Jackson, J.K. (1971): Nursery Techniques in the Savanna Region of Nigeria. In S.Kolade Adeytoyi and M.O. Odeyinde [ed] Proceeding of the second annual conference of the forestry association of Nigeria, zaria. 17-20th August, 1971. Pp 60-71.

King, K. F.S. [1977): Political Economy of Pulp and Paper. Unasylva 29 (19): pp.6-9.

Madu, A.S (1971): Nurseries and Plantations Diseases. FAO Report No. 1823.

MohdEderozey. A.M. Akil, H.M, Azhar AND ZainalAriffinn, M.I. (2007): Chemical Modification of Kenaf Materials Letters, vol(61), pp2023-2025.

Momoh, Z.O (1971): Pathological consideration in the economics of plantation establishments.In:S. Kolade Adeyoju and M.O Odeyinde (ed) Proceedings of the Second Annual Conference of the thus Forestry Association of Nigeria, Zaria. 17-20th August, 1971. pp 9-14.

Momoh, Z.O. (1970): The problems of Mycorrhiza establishment in the savanna zone in Nigeria. Paper Presented at the inaugural Conference of the Forestry Association of Nigeria, 1970.

Nkaa, F.A. Ogbonnaya, C.I. and N.B. (2004): "Effect of differential irrigation on physical and histochemical properties of Kenaf (Hibiscus cannabinus I.) Grown in the field in Eastern Nigeria," African J Agric. Resh 2 (6), pp252-260.

Ogunsile, B.O and C.F. Uwajeh (2009): Evaluation of pulp and paper potentials af a Nigerian grown *Bambusa vulgaris.* World Applied Science Journal 6(4) 536-541

Ogunwusi A.A. (2002): Wood properties of *Sterculia Setigera* forming in the savanna belt of Nigeria. Nig. J. for. 32(1), pp50-55.

Ogunwusi A.A. (2011): Strategies for increasing pulp and paper capacity in Nigeria. Journal of tropical forest resources 27 (1), pp31-46.

Ogunwusi, A.A and Uwajeh A.P. (2009): Indicative inventory of bamboo availability and utilization in Nigeria. JORDIN 9(2), pp1-9.

Ojo, G.O.A. (1971): Thoughts on tree improvement program for some savanna plantaion species. In S. Kolade Adeyoju and M.A. Odeyinde (ed) Proceedings of the Second Annual Conference of the Forestry Association of Nigeria. Zaria 17-20th August, 1971 pp146-150.

Oluwadare, A. O. and Egbewole, Z. T. (2008): Wood Quality Studies in Plantation Grown Steculia (*Steculia setigera*) in the Guinea Savannah, Nigeria. *Research Journal of Forestry.vol(*2): pp22-33.

Osadare O.A. (1997): Strategies For Long Fiber Pulp Production In Nigeria. *Nig. Jour. For.* 24(1and 2). pp16-20.

Osadare, A. O. (1996): Basic Wood and Pulp Properties of Nigerian-Grown Caribbean Pine (*Pinus caribea)* and their Relationships with Tree Growth Indices. PhD thesis, Department of Agricultural engineering, University of Ibadan, 417p

Osadare, A. O. and Udohitinah, J. S. (1993): Fibre Characteristics of some Nigerian Raw Materials for Long Fibre Pulp Production. In: Forestry for Urban and Rural Development in Nigeria, Oduwaiye, E. A. (Ed). *FAN 23rd Conference*, Pp: 132-138.

Pande, H. (1998): Non Wood Fibre and Global Fibre Supply.Unasylva 193 (46): pp44-50.

Sotannde, A. O. (2000): Preliminary Investigation into the Fibre Characteristics of *Thaumatococcusdanielli*. A dissertation submitted to the Department of Forest Resource Management for the award of Bachelor of Forestry Degree, University of Ibadan. 59p.

Patil, J.V., Appaji Chari, Rao, S.V., Maththur, R.M., Vimelesh, B. and Lal, P.S. (2011): High Biomass Sorghum (Sorghum bicolor) – An Alternative Raw Material for Pulp and Paper Making In India. IPPTA J. 23(2): pp161-165.

Picornelli, P.M. (1984): Protecting new pulp and paper industries: an opinion from developing countries. Unasylva 144: pp54-62.

RMRDC [1991]; Report of the Muliti-Disciplinary Task Force on Pulp, Paper, Paper Production, Printing and Publishing Sector. RMRDC Publication,1991.

RMRDC (2009): Raw Materials Sourcing for Manufacturing in Nigeria. 4th Edition. RMRDC publication.

Schumacher K., and Sathaye, J. (1999): India's pulp and paper industry: Productivity and Efficiency. A Report of the Earnest Orlando Lawrence Berkerly National Laboratory. LBNL-41843 pp37

Sharma, Vinod K,, K.V. Ramaswamy. R.R. Vaidaya, N. Hadker and P. van Beukering (1998). The Indian Paper industry In P. van Beukering, Peter van, Vinod K. Sharma (ed). Waste Paper Trade and Recycling in India, Jodhpur, India Scientific Publishers.

Udohitinah and Oluwadare (2001). "Kenaf kraft pulp". BioResources 6(1), pp751-761.

Assessment of Forest Policy Formulation and Implementation in Liberia

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ABSTRACT

Forest policy formulation and implementation (FPFI) involving stakeholders are a policy approach for good forest governance. Effective participatory FPFI ensure sustainable forest management. However, inclusive FPFI have been weak institutional elements over the years retarding the development of the forestry sector in Liberia. Therefore, Liberia forest policy formulation and implementation were assessed to elicit views of stakeholders for more effective forest management. Total enumeration of forest officials and multi-stage sampling of community dwellers were used for the study. One hundred and ninety-one forest officials and 657 community dwellers from 24 communities were selected using proportionate sampling. Two sets of structured questionnaire were used to obtain data on forest governance criteria: Equity and Justice (EJ), Transparency, Gender Equality (GE), Continuous Improvement (CI), Consultation and Participation (CP), Rule of Law (RL), Holistic and Sustainable Approach (HSA) and Accountability. Data were analyzed using logit regression at α 0.05. The forest governance criteria that negatively impacted forest policy formulation and implementation for good forest governance in Liberia were HSA, Transparency and CI with odds-ratio of 2299.70, 1110.99 and 319.48, respectively. Inadequate HSA, lack of transparency and non-CI negatively impacted forest policy formulation and implementation for good forest governance in Liberia. There is urgent need for adherence to criteria for forest policy formulation and implementation for good forest governance.

Keywords: Forest governance, policy approach, institutional elements, sustainable forest management

INTRODUCTION

Forest resource policies are pivotal in harnessing forest resources for national development. They are part of public policies which are basically outcomes of decisions reached by governments or state elite to sustainably utilize forest resources for the benefit of society (Onyeoziri, 2005). Therefore, the formulation and implementation of forest policies are often initiated and heavily influenced by governments at every level, and for this reason forest policy objectives invariably reflect the aspirations of the political system of a country. In view of this, it is essential for forest policy experts to have considerable political knowledge since the policy process is usually influenced by the imperatives of the political environment within which the policymakers exist (Yagboyaju, 2008). According to Sambo (1999), the policy process is a long chain of activities involving various factors such as clarity of policy concept, focus and goal specification, validity of policy framework, purposive implementation, analysis, effective monitoring, and alternative plans of action in case of policy failure or negative consequences. However, policy failure can be avoided because policy experts have at their disposal already crafted policymaking models.

In forestry, policymakers often adopt the rational and incremental models. A rational model assumes that policies are selected after a thorough analysis of alternatives on the basis of clear criteria while the incremental model suggests that policies are formulated only as a small variation from past policies, with little analysis of programme alternatives (Cubbage *et al*, 1993). However, they observed further that the political criteria ultimately determine which policy is selected and implemented since politicians must authorize programmes and appropriate funds; for this reason even alternatives that meet all other criteria may not be implemented.

Arifalo (2005) defined forest policy as a plan of action that is designed to indicate what proportion of a country's land should be developed and dedicated to forestry and how the products of the forests should be utilized for public good. The author stated further that forest policy encompasses mainly directions or actions related to the development of forestry in the context of the national economic development as adopted and pursued by the national economy. Cubbage *et al* (1993) succinctly agreed that forest policy is a means societies use to decide how forests will be used and who will benefit from their use.

Reaching such a decision is not easy due to the complex nature of forests and many stakeholders. To begin with, policymakers must have full knowledge of the forests and the interest groups. This implies consultations with stakeholders as well as a comprehensive research work on everything that concerns the natural resources to avoid conflicts. Forest policies affect forest resource management and the people who use the forests, so for workable/acceptable forest policies policymakers must also take into consideration the people.

The method of forest policy enunciation in the past was not participatory in Liberia. Policy pundits simply refer to such a method today as a top-down approach (NFPIS, 2006). Consequently, objectives of past forest policies only guaranteed the interests of policymakers or political establishments and lobbyists. Describing a typical forest policy formulation environment in former British colonies, Troup (1940) revealed that forest policies were made by the colonial governments without even the inputs of forestry departments; the policies were only handed down to the forestry departments for implementation. Nonetheless, there has been a transition over the last two decades and a half from that authoritarian decision-making process in forestry to an inclusive forest enunciation and implementation process due to the current sustainable forest management paradigm, which cannot be effective without the involvement of all forest stakeholders in decisions that affect the resources (McCay, 2000).

Therefore, forest policymakers who do not adhere to good forest governance criteria will create a suitable environment for conflict among stakeholders particularly forest-based communities during the implementation stage. In other words, the lack of stakeholders' inputs amounts to the imposition of forest policy on stakeholders. Therefore, forest policy formulation and implementation for good forest governance criteria were assessed in Liberia with the view to establishing a solid foundation for sustainable forest management for the benefit of all interest groups.

METHODOLOGY

Study Area

Four national forests and two protected areas namely, Grebo, Gola, Krahn-Bassa and North Lorma National Forests; and Sapo National Park (SNP) and East Nimba Nature Reserve (ENNR) were purposively selected across the four forest regions in Liberia (Figure 1).



Figure 1: Map of Liberia showing the study areas

Sampling Technique and Size

Complete enumeration and multistage samplings were carried out through the use of two sets of structured questionnaire and interview guides to collect data from forestry field staff in the Four Administrative Regions of the Forestry Development Authority and community dwellers in the four national forests and two protected areas. Secondary data were also collected from official documents such as files and annual reports. A total of 848 copies of questionnaire were administered in the study areas. Eight hundred and thirty (98.11%) copies were filled and returned while 18 copies (2.12) were not returned (Table 1).

Table 1: Questionnaires Administered and Responses from the Stakeholders in Liberia

Forest Regions in Liberia	Total Number of Questionnaires Administered (N)	Total Number of Questionnaires returned (n)
Region 1	108	106
Region 2	128	126
Region 3	254	250
Region 4	356	348
Total (Regions)	848 (100%)	830 (98.11%)

Source: Field survey, 2014/2015
N= Total number of questionnaires administered
n = Number of questionnaires responded to by stakeholders

Data Analysis

The data obtained were collated and sorted, while coding sheets were prepared for respective data. Inferential statistics such as Logit Regression was used for the 830 respondents in the four national forests and two protected areas across the Four Forest Administrative Regions to assess the conformity of Liberia forest policy formulation and implementation to the criteria for good forest governance. The two possible results were assigned values of 1 (Yes) or 0 (No) in binary choice models. In the investigation, respondents' indication of presence of a variable was assigned a value of 1 and respondents' indication of absence of a variable was assigned the value of 0. Models to be tested were obtained by fitting all the independent variables together and backward elimination was done to obtain the best subset model. Emphasis was laid on (1) keeping the model as simple as possible and (2) selecting combinations of independent variables that made practical sense. The criteria investigated were Equity and Justice (*EJ*), Gender Equality (*GE*), Holistic and Sustainable Approach (*HSA*), Consultation and Participation (*CP*), Rule of Law (*RL*), Transparency (*T*), Accountability (*A*), and Continuous Improvement (*CI*). The study involved fitting all the criteria assessing *FPFIGFG* together and then elimination was done to obtain the best subset models. The resulting logit models were evaluated using the chi-square goodness-of-fit statistics (Ostle, 1963; Bruhn *et al*), the final loss on accuracy using maximum likelihood estimation method and odds ratio (Deeks, 1996; Davies *et al*, 1998). Binary models are very useful in situations where the dependent or response variable is binary in nature. This means that they can only have two possible values. In addition, Logit Regression provides information on the consequences of one variable on the other. Therefore, it would obviously show the variable or variables which mostly support or conform to *FPFIGFG*.

The logit of a response *p* between 0 and 1 is given as:

$$Logit(p) = log(p/1-p) = log(p) - log(1-p)$$

The simplest form of logit model is expressed as:

$$logit(p_i) = a + bx_i$$ …….. ……Equation 1

Where,

x_i = vector of predictor or independent variables

p_i = probability of a respondent indicating whether there is *FPFIGFG*

a and b = regression parameters

Criteria for Conforming to *FPFIGFG*

The dependent variable was *FPFIGFG* while the independent variables were *EJ*, *GE*, *HSA*, *CP*, *RL*, *T*, *A*, and *CI*.

FPFIGFG = Forest Policy Formulation and Implementation for Good Forest Governance: Presence (1) Absence (0)

EJ = Equity and Justice with respect to involving representatives of all stakeholders in policy formulation and implementation: Presence (1) Absence (0)

GE = Gender Equality: Any balanced participation of both males and females during the forest policy formulation and implementation?: Presence (1) Absence (0)

HSA = Has the approach adopted during the forest policy formulation and implementation been Holistic and Sustainable: Presence (1) Absence (0)

CP = Have there been adequate stakeholders' Consultation and Participation during the forest policy formulation and implementation?: Presence (1) Absence (0)

RL = Are the forest policy formulation and implementation regarding creation of national forests and protected areas in line with Rule of Law such that individual landed properties have not been forcefully included in the forest estate ? Presence (1) Absence (0).

T = Has there been Transparency in terms of dealing with all interest groups at the time of policy formulation and implementation: Presence (1) Absence (0).

A = Any provision on Accountability at the time of the forest policy formulation and implementation?: Presence (1) Absence (0)

CI = Was a provision enshrined in the new forest policy during the formulation for periodic reviews during implementation to ensure Continuous Improvement?: Presence (1) Absence (0).

Forest Regions used for the Study

1. Forest Region 1 = Location of respondents (Gola National Forest =1)……. ……..equation 2
2. Forest Region 2 = Location of respondents (North Lorma National Forest =2)……..….equation 3
3. Forest Region 3 = Location of respondents (Krahn-Bassa National Forest = 3; ENNR = 4) .equation 4
4. Forest Region 4 = Location of respondents (Grebo National Forest = 5; SNP = 6) ……equation 5
5. All Forest Regions = Location of respondents (Western Liberia = 1; Northern Liberia =2; Central Liberia =3; Southeastern Liberia = 4) ……..equation 6

RESULTS AND DISCUSSION

Table 2: Logit Binary Nature of Criteria for Forest Policy Formulation and Implementation for Good Forest Governance in Liberia (Forest Region 1)

Dependent Variable (*FPFIGFG*) = Forest Policy Formulation and Implementation for Good Forest Governance (Presence =1; Absence = 0)		
Independent Variables	Coefficient	Odds-ratio
Whether presence of *EJ* will make Policy Formulation and Implementation conform to Good Forest Governance	-1.73	0.18
Whether presence of *GE* will make Policy Formulation and Implementation conform to Forest Governance	-37.26	53887.85*
Whether presence of *HSA* will make Policy Formulation and Implementation conform to Forest Governance	-18.53	0.00
Whether presence of *CP* will make Policy Formulation and Implementation conform to Good Forest Governance	-6.02	0.00
Whether presence of *RL* will make Policy Formulation and Implementation conform to Forest Governance	-6.02	0.00
Whether presence of *T* will make Policy Formulation and Implementation conform to Forest Governance	-6.42	0.00
Whether presence of *A* will make Policy Formulation and Implementation conform to Forest Governance	-5.52	0.00
Whether presence of *CI* will make Policy Formulation and Implementation conform to Forest Governance	-6.35	0.00
Model X^2 (df=10) = 87.19*		

*= Significant at p<0.05

Table 3 Logit Binary Nature of Criteria for Forest Policy Formulation and Implementation for Good Forest Governance in Liberia (Forest Region 2)

Dependent Variable (*FPFIGFG*) =Forest Policy Formulation and Implementation for Good Forest Governance (Presence =1; Absence=0)		
Independent Variables	Coefficient	Odds-ratio
Whether presence of *EJ* will make Policy Formulation and Implementation conform to Good Forest Governance	-11.08	0.00
Whether presence of *GE* will make Policy Formulation and Implementation conform to Forest Governance	7.95	2847.14*
Whether presence of *HSA* will make Policy Formulation and Implementation conform to Forest Governance	-42.26	0.00
Whether presence of *CP* will make Policy Formulation and Implementation conform to Good Forest Governance	-31.75	0.00
Whether presence of *RL* will make Policy Formulation and Implementation conform to Forest Governance	-8.28	0.00
Whether presence of *T* will make Policy Formulation and Implementation conform to Forest Governance	12.93	0.00
Whether presence of *A* will make Policy Formulation and Implementation conform to Forest Governance	11.90	0.00
Whether presence of *CI* will make Policy Formulation and Implementation conform Good Forest Governance	-10.50	0.00
Model X^2 (df=10) = 87.19*		

*= Significant at p<0.05

Models 2 and 3 above for Forest Regions 1 and 2 in Western and Northern Liberia gave significant fit to the data judging from χ^2 value that was significant at p<0.05. Gender Equality (*GE*) was significant with odd-ratios of 2847.14 and 53887.85 for Forest Regions 1 and 2 respectively (Table 2 and 3).

Table 4: Logit Binary Nature of Criteria for Forest Policy Formulation and Implementation for Good Forest Governance in Liberia (Forest Region 3)

Dependent Variable (*FPFIGFG*) =Forest Policy Formulation and Implementation for Good Forest Governance (Presence =1; Absence=0)

Independent Variables	Coefficient	Odds-ratio
Whether presence of *EJ* will make Policy Formulation and Implementation conform to Good Forest Governance	-1.69	0.19
Whether presence of *GE* will make Policy Formulation and Implementation conform to Good Forest Governance	-2.04	0.13
Whether presence of *HSA* will make Policy Formulation and Implementation conform to Forest Governance	- 4.45	0.01
Whether presence of *CP* will make Policy Formulation and Implementation conform to Forest Governance	7.04	1140.69*
Whether presence of *RL* will make Policy Formulation and Implementation conform to Forest Governance	9.73	16854.70*
Whether presence of *T* will make Policy Formulation and Implementation conform to Forest Governance	-1.49	4.42*
Whether presence of *A* will make Policy Formulation and Implementation conform to Forest Governance	0.90	2.46*
Whether presence of *CI* will make Policy Formulation and Implementation conform to Forest Governance	-5.38	0.00
Model X^2 (df=10) = 87.19*		

*= Significant at p<0.05

Table 5: Logit Binary Nature of Criteria for Forest Policy Formulation and Implementation for Good Forest Governance in Liberia (Forest Region 4)

Dependent Variable (*FPFIGFG*) =Forest Policy Formulation and Implementation for Good Forest Governance (Presence =1; Absence=0)

Independent Variables	Coefficient	Odds-ratio
Whether presence of *EJ* will make Policy Formulation and Implementation conform to Good Forest Governance	-1.83	0.16
Whether presence of *GE* will make Policy Formulation and Implementation conform to Good Forest Governance	-0.79	0.46
Whether presence of *HSA* will make Policy Formulation and Implementation conform to Forest Governance	-1.65	0.19
Whether presence of *CP* will make Policy Formulation and Implementation conform to Forest Governance	0.77	2.15*
Whether presence of *RL* will conform to Policy Formulation and Implementation for Forest Governance	0.57	0.57
Whether presence of *T* will conform to Policy Formulation and Implementation for Forest Governance	-1.53	0.22
Whether presence of *A* will conform to Policy Formulation and Implementation for Forest Governance	1.03	2.80*
Whether presence of *CI* will make Policy Formulation and Implementation conform to Forest Governance	5.39	218.07*
Model X^2 (df =10) = 87.19*		

*= Significant at p<0.05

Models 4 and 5 presented above for Forest Regions 3 and 4 in Central and Southeastern Liberia indicated overall significant fit to the data judging from χ^2 value was significant at p<0.05. Rule of Law (*RL*), and Consultation and Participation were significant with odd-ratios of 16854.70 and 1140.69 followed by Accountability (*A*) and Transparency (*T*) with respective odd-ratios of 4.46 and 2.42. Continuous Improvement (*CI*), Accountability (*A*), and Consultation and Participation (*CP*) were significant in Forest Region 4 with 218.07, 2.08 and 2.15 respectively (Tables 4 and 5).

Table 6: Logit Binary Nature of Criteria for Forest Policy Formulation and Implementation for Good Forest Governance in Liberia (All Forest Regions)

Dependent Variable (*FPFIGFG*) =Forest Policy Formulation and Implementation for Good Forest Governance (Presence =1; Absence=0)		
Independent Variables	Coefficient	Odds-ratio
Whether presence of *EJ* will make Policy Formulation and Implementation conform to Good Forest Governance	-3.523	0.03
Whether presence of *GE* will make Policy Formulation and Implementation conform to Good Forest Governance	-5.33	0.01
Whether presence of *HSA* will make Policy Formulation and Implementation conform to Forest Governance	-0.12	2299.70*
Whether presence of *CP* will make Policy Formulation and Implementation conform to Good Forest Governance	-4.58	0.83
Whether presence of *RL* will make Policy Formulation and Implementation conform to Forest Governance	-4.58	0.01
Whether presence of *T* will make Policy Formulation and Implementation conform to Forest Governance	7.01	1110.99*
Whether presence of *A* will make Policy Formulation and Implementation conform to Forest Governance	-1.22	0.30
Whether presence of *CI* will make Policy Formulation and Implementation conform to Forest Governance	5.77	319.48*
Model X^2 (df=10) = 87.19*		

*= Significant at p<0.05

Model 6 above for all the Forest Regions in Liberia gave overall significant fit to the data judging by χ^2 value that was significant at p<0.05. Holistic and Sustainable Approach (*HSA*) was the most significant variable with odd-ratio of 2299.70 followed by Transparency (*T*) and Continuous Improvement (*CI)* with odd-ratios of 1110.99 and 319.48 respectively (Table 6).

DISCUSSION

Criteria for Forest Policy Formulation and Implementation for Good Forest Governance in Forest Regions 1 and 2 in Western and Northern Liberia

Gender Equality (*GE*) was the only significant criterion in Forest Regions 1 and 2. There was sufficient evidence that the estimated coefficients for the criterion in each forest region were not zero. This implies that the regression parameters in the models were significant. The higher the values of odd-ratios, the more likelihood for the criteria required for Forest Policy Formulation and Implementation for Good Forest Governance. Hence, Gender Equality (*GE*) is the criterion required for Forest Policy Formulation and Implementation for Good Forest Governance in Forest Regions 1 and 2 in Western and Northern Liberia in terms of ensuring equal representation of all stakeholders regardless of gender. This result is in line with Deeks (1996); Bland and Altman (2000) that the logit model provides information on the consequences of one variable on the other.

Forest Regions 3 and 4 in Central and Southeastern Liberia

In Forest Region 3, Rule of Law (*RL*), Consultation and Participation (*CP*), Transparency (*T*), and Accountability (*A*) were the significant criteria whereas Continuous Improvement (*CI)*, Accountability (*A*), and Consultation and Participation (*CP)* were significant in Forest Region 4. There was enough evidence that the estimated coefficients for the criteria were not zero. This implies that the regression parameters in the models were significant. The higher the values of odd-ratios, the more likelihood for the criteria required for Forest Policy Formulation and Implementation for Good Forest Governance. This indicates that Rule of Law (*RL*), Consultation and Participation (*CP*), Transparency (*T*), and Accountability (*A*) as well as Continuous Improvement (*CI)*, Accountability (*A*), and Consultation and Participation (*CP)* are the criteria needed for the enhancement of Forest Policy Formulation and Implementation for Good Forest Governance in Forest Regions 3 and 4 in Central and Southeastern Liberia. This finding agrees with the investigations of Deeks (1996); Bland and Altman (2000) that the logit model gives clear information on the consequences of the independent variables on the dependent or response variable.

All Forest Regions

In all the Forest Regions, the significant criteria were Holistic and Sustainable Approach (*HSA*), Transparency (*T*), and Continuous Improvement (*CI)*. There was enough evidence that the estimated coefficients for the criteria were not zero. This implies that the regression parameters in the model were significant. The higher the values of odd-ratios, the more likelihood for the criteria required for Forest Policy Formulation and Implementation for Good Forest Governance. This result suggests that Holistic and Sustainable Approach (*HSA*), Transparency (*T*), and Continuous Improvement (*CI)* will enhance Forest Policy Formulation and Implementation for Good Forest Governance throughout all the Forest Regions in Liberia. This is corroborated by Deeks (1996); Bland and Altman (2000) that the logit model indicates the effect of one variable on the other.

CONCLUSION AND RECOMMENDATION

Conclusion

There were variations in each forest region with respect to criteria required for forest policy formulation and implementation for good forest governance. However, throughout the four forest regions, Holistic and Sustainable Approach (*HSA*) was the most significant criterion required. This was followed by Transparency (*T)* and Continuous Improvement (*CI)*. Hence, the Liberian Government should, as a matter of necessity, re-invigorate the Forestry Development Authority to enable it adhere to these criteria to further promote good governance in managing the country's forest resources.

Recommendation

The following recommendation is made based on the findings of the study:
The National Legislature must debate and pass bills on criteria such as Holistic and Sustainable (*HSA*), Transparency (*T)*, and Continuous Improvement (*CI)* that mostly contribute to forest policy formulation and implementation for good forest governance (*FPFIGFG)* as an instrument for good governance in the forestry sector.

REFERENCES

Arifalo, I.E. 2005. *Understanding Forest Policy*. Published by praclete publishers, Yola, Nigeria. Pp.121-122.

Bland, J.M. and Altman, D.G. 2000."The odds ratio" *British Medical Journal* 230,148.

Bruhn, J.N; Pickens, J. B. and Stanfield, D.B. 1991. Probit analysis of oak with transmission through root grafts in red oak stands. *Forest Science* Vol. 37. No. 1. Pp.28-44.

Cubbage, F.W, O'Laughlin,J, Bullock III, C.S.1993. *Forest resources policyt.* Published by Fohn Wiley & Sons, Inc. New York, USA. Pp. 18. 36-49.

Davis, H.T.O, Crombie, I.K. and Tavakoli, M. 1998. When can odds ratios mislead? *British Medical Journal* Vol. 316, 989-991.

Deeks, J. 1996. *Swots corner: What is an odds ratio*? Banddolier books Vol. 3(3), Issue 25, Pp. 6-7.

Liberia Forest Re-assessment. 2004. A map produced by Ministry of Planning and Economic Affairs, Forestry Development Authority, Environmental Agency, Fauna & Flora International and Conservation International.

McCay, B. J. 2000. Post-modernism and management of natural and common resources. *The Common Property Resource Digest* Vol. 54. In: *Forest policy for private forestry: Global and regional challenges*. Pp.1-8.

National Forest Policy and Implementation Strategy (NFPIS). 2006. Published by Forestry Development Authority & Ministry of Finance, Monrovia, Liberia. Pp. 13-21.

Onyeoziri, F. 2005. *Alternative policy option for managing the national question in Nigeria*. Published by John Archers Ltd. Pp. 8-9.

Ostle, B. 1963. *Statistics in research* Ed.2. The 1owa State University Press Ames. Pp. 585.

Sambo, A. 1999. *What is public policy?.* In. Remi Anifowose and Emenuo (eds.). Elements of politics. Published by Sam Iroanusi. Pp.2.

Troup, R.S. 1940. *Colonial forest administration.* Published by Oxford University Press, UK. Pp. 317.

Van der Kraaij, F.P.M. 1983. *The open door policy of Liberia: An economic history of modern Liberia.* Published by Reihe F Bremen Afrika Archiv Band 17/1. Pp. 259-268.

Yagboyaju, D. A. 2008. *Issues in public policy in Nigeria*. Published by College Press and Publishers Ltd. Jericho GRA, Ibadan, Pp. ix, 1, 2, 3,8, 15,16.

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Impact of Involvement of Stakeholders in Forest Policy Implementation in Southwestern Nigeria

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ABSTRACT

This study evaluated the impact of involvement of stakeholders in forest policy formulation and implementation in Southwestern Nigeria. The primary data were collected through the use of structured questionnaire and Focus Group Discussions to gather relevant data from the forest stakeholders in Lagos, Ogun, Oyo, Osun, Ondo and Ekiti States of Southwestern Nigeria.The respondents were made up of Forest Officers, Sawmillers, Timber Contractors and Forest Community. The data were analysed using descriptive statistics. The results revealed that only 16% of the saw-millers and 10.0% of the timber contractors indicated that they were involved in decision-making processes as regards the forest reserves. Respondents (30.3%) of the sampled Rural Dwellers in forest community indicated that they were involved in decision-making. In all, 35.0 % of the Forestry Officials, 32.0 % among the Sawmillers, 34.0 % among the Timber Contractors and 41.0 % among the rural people in the forest reserves perceive the forestry policy implementation as adequate. There is need for adequate involvement of stakeholders in policy formulation towards sustainable forest management. It is recommended that the nation should review its existing forest policy and approve a unified National Forest Policy in line with the emerging forest issues as well as sustainable management of the forest estate.

Keywords: Forest policy, forest stakeholders, involvement, forest estate, decision-making

INTRODUCTION

Forest management in Nigeria started in earnest in the last 18th century with the establishment of regional forestry authorities, followed by a period of nearly 60 years of forest reservation, introduction of timber licensing systems, development of royalty determination systems, introduction and development of silviculture and silvicultural systems in natural forests, achievement of reliable regeneration methods, establishment of plantations, development of fire protection practices and the building up from scratch of forestry and forestry education at technical and tertiary levels (FAN, 1989).

The main objective of forest management in any country is usually the attainment of sustainable management of forest resources as well as self-sufficiency in forest produce particularly wood. In Nigeria, the broad policy objectives include sustainable forest management, forest conservation and environmental protection (Adeyoju 1975; Bada, 1996). Subsequently, other issues became important including utilization of forest products; development of non-wood forest products that play significant roles in rural economy thereby creating employment and income, creation of alternative source of energy other than wood and; international cooperation for forestry development among other things. Over-exploitation has destroyed the recuperative capacity of the forests including non-timber produce collected from the forest. The obvious fact is that the remaining natural forest cannot cope with the rapidly decreasing area of exploitable forest and high prices for timber exports.

Over the last 56 years of independence in Nigeria, there has been a significant shift from long term pursuance of policy objectives to inconsistent and epileptic management (Agbeja, 1999, Faleyimu, 2010). However, the national forest policy recommended for Nigeria in 1988 has the basic principles, which should guide the development and control of forestry in Nigeria (FAN, 1989). This study evaluates the involvement of stakeholders in forest policy formulation and implementation in South-west Nigeria with the view to facilitating sustainable forest management in the country.

METHODOLOGY

Study Area

The study was carried out in Six States of Southwestern Nigeria.Tthese include Lagos, Ogun, Oyo, Osun, Ondo and Ekiti States. The area has 85 constituted Forest reserves with a forest area cover of 842,499 hectares.

Sampling of Forestry Stakeholders

Both primary and secondary data were used for the study. The primary data were collected through the use of structured questionnaire and focus group discussions to gather relevant data from forest stakeholders in the selected States. The secondary information was obtained from desk review of literatures on forest policy in Nigeria. The respondents were made up of forest officers, saw-millers, timber contractors and forest community. One Officer in charge of each administrative zone was selected and 20 percent of forestry officials from each of the State headquarters; this gives a total of 152 officials. Ten percent of the registered timber contractors were randomly selected in the forestry zones within each of the states. The samples were collected pro-rata, according to the population of the timber contractors in each zone. Thus, for the six states, 10 percent sampling yielded a total of 128 timber contractors. Ten percent of the registered saw-millers were randomly selected from each State across the zones. The number of sawmillers arrived at is presented was 201. A total of 251 dwellers in local communities located in selected forest reserves in each of the states were randomly sampled. These people constitute a major stakeholder because they live within the forest reserve and directly have impacts on the state of the forests.

Data Analysis

The data were analysed using descriptive statistics such as frequency tables, bar charts and histograms.

RESULTS

Stakeholders' Involvement in Decision Making on Forestry Issues

Sixteen perecent of the saw-millers and little above 10.0% of the timber contractors indicated that they were involved in decision-making processed as regards the forest reserves as shown in Table 1. The highest among the Saw millers was in Ekiti State where 40.0 % of the saw-millers indicated that they were involved and this was followed by 31.0% of the saw millers in Oyo State while only 2.9% of the saw millers in Osun State, which had the least percentage, indicated they were involved. Among timber contractors, Lagos State had the highest number of contractors (20.0%) who pointed out that they were involved in decision-making while Ekiti State had the least (5.6 %).

Table 1: Involvement of Forest Stakeholders in Decision-Making

	Saw miller						Timber Contractors					
	Involvement in Decision-Making						Involvement in Decision-Making					
	No		Yes		Total		No		Yes		Total	
State	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Ekiti	12	60.0	8	40.0	20	100.0	17	94.4	1	5.6	18	100.0
Lagos	30	88.2	4	11.8	34	100.0	4	80.0	1	20.0	5	100.0
Ogun	37	84.1	7	15.9	44	100.0	27	87.1	4	12.9	31	100.0
Ondo	35	94.6	2	5.4	37	100.0	20	87.0	3	13.0	23	100.0
Osun	33	97.1	1	2.9	34	100.0	25	92.6	2	7.4	27	100.0
Oyo	22	68.8	10	31.3	32	100.0	20	83.3	4	16.7	24	100.0
Total	**169**	**84.1**	**32**	**15.9**	**201**	**100.0**	**113**	**88.3**	**15**	**11.7**	**128**	**100.0**

Involvement of Forest Community in Decision-Making by Forestry Officials

Figure 1 showed responses of forestry officials on the involvement of forest community in decision-making. From the combined result, only 30.3% of the sampled rural dwellers in forest community indicated that they were involved in decision-making and this was highest in Ogun State with 42.1% of the officials indicated that they involved the community in decision-making while the least was just about 15.0% in Ekiti State.

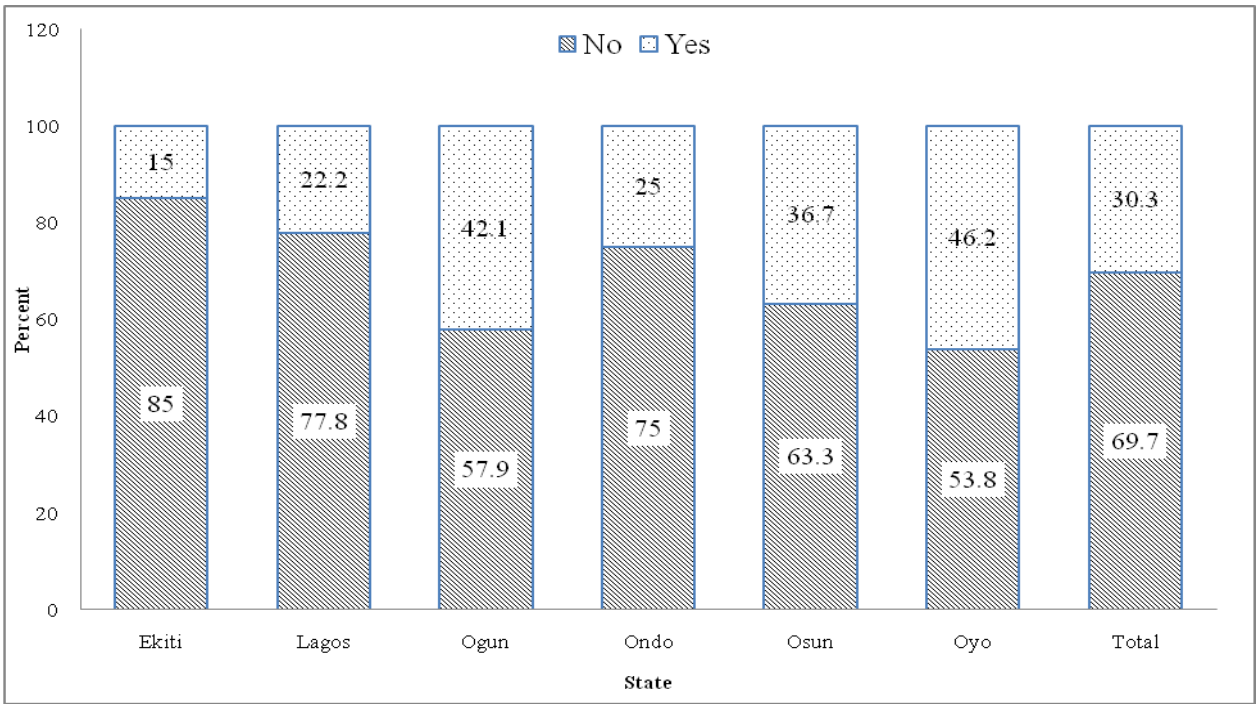


Figure 1: Responses of Forestry Officials on Involvement of Forest Community in Decision- Making

Forest Policy Objectives Implementation in Southwestern Nigeria

Figure 2 showed responses of forestry stakeholders on level of implementation of forest policy in southwest Nigeria. In all, about 35.0 % of the forestry officials, 32.0 % among the saw millers, 34.0 % among the timber contractors and 41.0 % among the rural people in the forest reserves perceive the forestry policy implementation as adequate. The responses across the states were almost similar, as 39.0 % of the forestry officials in Ondo State indicated that the forest policy implementation is adequate, while 47.0 % of the saw miller in Oyo State also view the policy implementation as adequate. Furthermore, 41.0 % of timber contractors in Osun State view the policy implementation as adequate while 62.0 % of the farmers in Oyo State view the policy implementation as adequate.

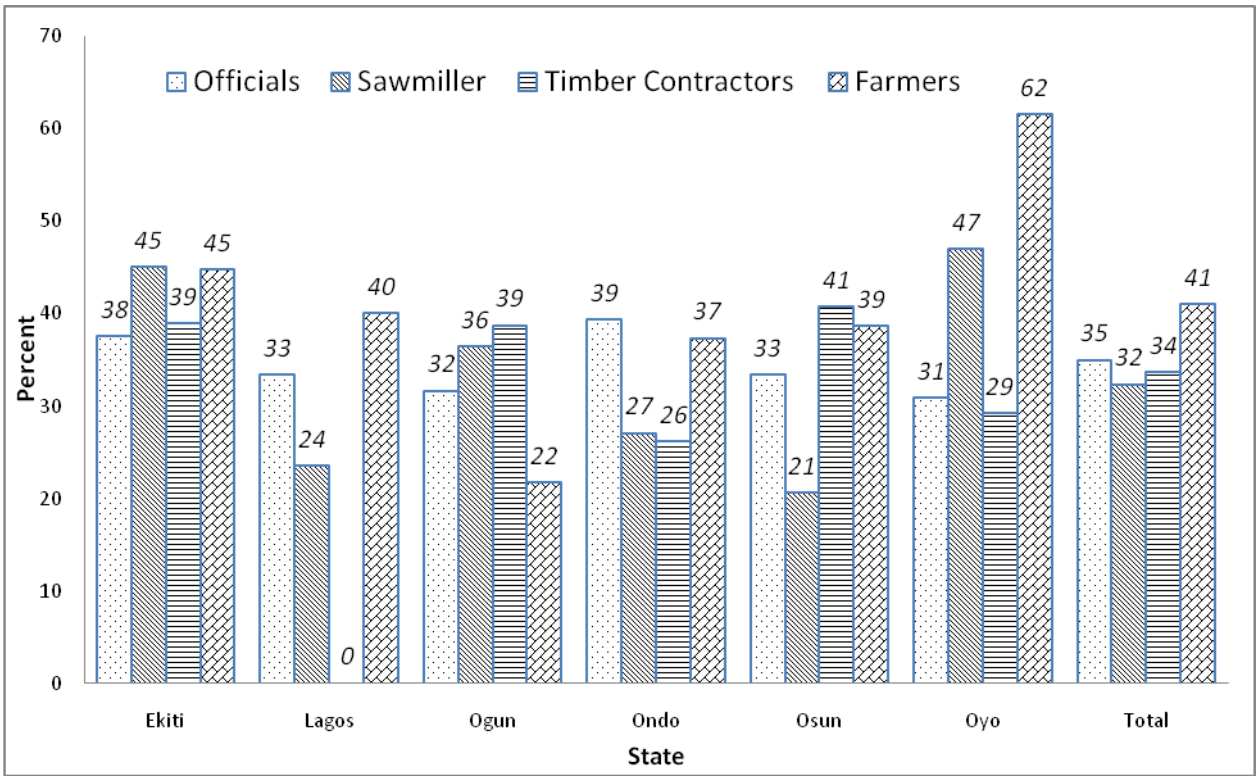


Figure 2: Responses of Forestry Stakeholders on Appropriate Implementation of Forest Policy in Southwestern Nigeria

Implementation of Specific Aspects of Forestry Policy

Across all the states, 28.4 % (47.0 % in Ekiti and 15.0 % in Ondo) viewed reservation of existing forest reserve as adequate; 42.6 % (50.0 % in Ekiti and Ogun and 33.0 % in Lagos) perceived value of forest policy as adequate as shown on Table 2. Concerning forest administration, 43.2 % (48.0 % in Ondo and 33.0 % in Lagos) viewed this law as adequate and just 18.9 % (30.0 % in Osun and 11.0 % in Ogun and Ondo) indicated provision of funds for the realization of forestry objectives was adequate. About 35.1 % (48.0 % in Ondo and 24.0 % in Ekiti) indicated that provision of forest estate policy was adequate and more 65.0 % (89.0 % in Ogun and 48.0 % in Ondo) considered mutual interdependence of forestry and forestry industry policy as adequate. Research and education on forestry policy was considered adequate by 40.5 % (44.0 % in Ogun and Ondo and 31.0 % in Oyo); and, 44.6 % (50.0 % in Ekiti and 22.0 % in Lagos) considered private forest policy adequate. Employment policy was considered by 29.7 % (33.0 % in Osun and 11.0 % in Lagos) of the forest officials as adequate.

Table 2: Responses on Adequacy of Forestry Policy as Indicated by the Forestry Officials across Six States

		State													
	Response	Ekiti		Lagos		Ogun		Ondo		Osun		Oyo		Total	
Forest Policy		N	%	N	%	N	%	N	%	N	%	N	%	N	%
Reservation of existing forest reserve	Yes	18	47.4	3	33.3	4	22.2	4	14.8	7	23.3	6	23.1	42	28.4
	No	20	52.6	6	66.7	14	77.8	23	85.2	23	76.7	20	76.9	106	71.6
Value of forest	Yes	19	50	3	33.3	9	50	10	37	14	46.7	8	30.8	63	42.6
	No	19	50	6	66.7	9	50	17	63	16	53.3	18	69.2	85	57.4
Forest administration	Yes	17	44.7	3	33.3	7	38.9	13	48.1	12	40	12	46.2	64	43.2
	No	21	55.3	6	66.7	11	61.1	14	51.9	18	60	14	53.8	84	56.8
Provision of funds for the realization of forest objectives	Yes	7	18.4	2	22.2	2	11.1	3	11.1	9	30	5	19.2	28	18.9
	No	31	81.6	7	77.8	16	88.9	24	88.9	21	70	21	80.8	120	81.1
Provision of forest estate	Yes	9	23.7	4	44.4	5	27.8	13	48.1	11	36.7	10	38.5	52	35.1
	No	29	76.3	5	55.6	13	72.2	14	51.9	19	63.3	16	61.5	96	64.9

Mutual interdependence of	Yes	28	73.7	6	66.7	16	88.9	13	48.1	18	60	16	61.5	97	65.5
forestry and forest industry	No	10	26.3	3	33.3	2	11.1	14	51.9	12	40	10	38.5	51	34.5
Research and education on	Yes	16	42.1	3	33.3	8	44.4	12	44.4	13	43.3	8	30.8	60	40.5
forestry science and management	No	22	57.9	6	66.7	10	55.6	15	55.6	17	56.7	18	69.2	88	59.5
	Yes	19	50	2	22.2	7	38.9	13	48.1	14	46.7	11	42.3	66	44.6
Private forest	No	19	50	7	77.8	11	61.1	14	51.9	16	53.3	15	57.7	82	55.4
	Yes	15	39.5	1	11.1	4	22.2	7	25.9	10	33.3	7	26.9	44	29.7
Employment	No	23	60.5	8	88.9	14	77.8	20	74.1	20	66.7	19	73.1	104	70.3
Total		38	100	9	100	18	100	27	100	30	100	26	100	148	100

DISCUSSION

The Federal Republic of Nigeria consists of 36 states and Abuja, Federal Capital Territory (FCT). Each of the states and the FCT has an established forestry services as division under the appropriate Ministry. Each State Forest Service (SFS) is responsible for setting and administering policies for its forests. Each SFS Department is headed by a Director reporting to the Permanent Secretary, who reports to the Commissioner i.e. the Chief Executive Officer of the Ministry in the state (Aruofor, 2001).Generally, it was observed that the forestry stakeholders perceive implementation of forest policies as being inadequate. About six in ten of all the stakeholders hold to the position that forest policy implementation was inadequate and hence, the gross misconduct observed in the forest reserves. Forestry laws of the Federal Republic of Nigeria stipulate that prosecution of forest offences, at the local government level, in courts of law is the function of the State Director of Forestry or an officer delegated by the Director, whose status should not be below the rank of Forest Superintendent (Agera*et al.*, 2009) but most of the forestry officials do not possess the constitution (or gazette) and this was observed as one of the factors influencing forest offences even among the officials. Most of the officials do not have the constitution and they may not be aware of the provisions of the forestry laws in prosecuting offences and they are likely to take laws into their hands or handle it wrongly.

There is no conducive atmosphere for effective operation of forest policy among the stakeholders in Nigeria (Ogunwusi, 2013). For instance, while the forest policy stipulated increase in economic wood availability in the forest reserves, gregarious deforestation has resulted in scarcity of economic wood species. As far back as 1899, the perspective planning for economic development was to exploit forest resources (Adeyoju, 1975). The export revenue from forestry grows at 4.1%, 8.0% and 28.8% between 1950-60, 1960-70 and 1970-80, respectively (Aribisala, 1993). Despite years of deforestation occasioned by dependence of the budget on wood and other forest resources export, the forest policy in Nigeria remains outdated and unable to effectively promote afforestation and development of industrial wood species (Ogunwusi, 2013). These developments have significant impact on the operations of the forest industries. Closely linked with this is the availability of fund for research and development of forestry sector. It is stipulated that certain percentage of income generated from forest exploitation should be ploughed back into management and regeneration activities, yet the forestry sector does not receive adequate funding to carry out official responsibilities. Consequences of this are wanton destruction of forest and loss of huge amount of revenue from illegal forest activities.

It is worrisome that Nigeria is still battling with the issue of National Forest Policy which was enunciated in 2006 but yet to be backed with National Forestry Act. This is greatly affecting development of the forestry sector in the country. The reason is that each state of the country manages its forest and there is no unified legal document to guide against disparities in the management strategy.

CONCLUSION AND RECOMMENDATION

The study has shown that majority of the forestry stakeholders are not involved in forest policy formulation and implementation in Nigeria. It is high time that the nation reviewed its existing forest policy and approves a unified National Forest Policy in line with the emerging forest issues as well as sustainably manages the forest estate. Also, there is need for adequate involvement of stakeholders in policy formulation and implementation because successes of forestry sector largely depend on cooperation of the stakeholders. In addition, the institutional framework and may be the constitutional changes in respect of forest ownership and development planning, as well as programme implementation should be revisited and strengthened.

The challenges call for private sector and public participation, the evolution of an appropriate national forestry legislation, aggressive and scientific forest management, capacity building and adequate financing of forestry development in Nigeria.

REFERENCES

Adeyoju, S.K. (1975), Forestry and the Nigeria Economy.Ibadan University press, Ibadan, Nigeria. 294pp.

Agbeja, B.O. (1999): Forestry Sector Analysis for Macro-Economic Development of Osun and Oyo States, Nigeria. Ph. D. Thesis, 270pp.

Agera, S., Adegeye, A. and Jimoh, S. O. (2009): Deforestation Trends in Forest Estates of Vandeikya Local Government of Benue State, Nigeria. Journal of Research in Forestry, Wildlife and Environment, 1 (1), 46-55. In: Kuemmerle, *et al.*(2009): Forest cover change and Illegal logging in the Ukrainian Carpathians in the transition period from 1988 to 2007.

Aribisala, A. O. (1993): Raw Materials Revolution and Impact on Industrialisation in Nigeria. Mednet Publications Ltd. (1993). ISBN 978 – 024 – 000 – 4

Aruofor, R., 2001. FOSA Country Report : Nigeria. Forestry Outlook Studies in Africa (FOSA). FAO, Rome. Retrieved 07/08/2013 from http://www.fao.org/docrep/004/ab592e/AB592E00.htm#TOC

Bada, S.O(1996): The Challenges of Forestry Development. A Role of Women in : Proceedings of Annual Workshop of Forestry Vocational Training Centre, Dorayi, Kano, 5-7 March, 1996.

FAN (1989): 100 years of Forestry Development in Nigeria, published by Forestry Association of Nigeria (FAN), Nov., 1989. Remote Sensing of Environment, 113 (2009), 1194-1207.

FAO (1991): Tropical Forests Action Programme, Rome.

Ogunwusi, A.A., 2013. The Impact of Forest Policy and Land Tenure System on Bamboo Development in Nigeria. Public Policy and Administration Research Vol.3, No.5: 13-20

Forest Offences among Stakeholders in Southwestern Nigeria: Implication for Sustainable Forest Management

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ABSTRACT

Illegal logging is a major problem for many timber-producing countries in the developing world. The damage caused by illegal activities and corrupt practices in the Nigerian forest is a problem of enormous proportion. The study therefore assessed forest offences among stakeholders and it implication on sustainable forest management in six states of Southwestern Nigeria with a view to recommending policy options for sustainable forest management. The selected states include Lagos, Ogun, Oyo, Osun, Ondo and Ekiti. The survey was conducted through the use of structured questionnaire and focus group discussions. The respondents were made up of forest officers, saw-millers, timber contractors, and people living within and around the forest reserves. Data were analysed using descriptive statistics. Identified Forest Offences in Forest Reserves were Illegal Felling of Trees (19.8%), Illegal Farming (18.9%), Arson (15.9%), Illegal Hunting (15.7%), Trespassing (15.2%) and Misuse of Pass-hammer (14.5%). There was no significant variation in the proportion of Forest offences across the States. Illegal felling of trees was the most common Forest offence among both the saw-millers (97.2%) and timber contractors (94.8%), while hunting in the reserves was the most common Forest offence among farmers (80.0%). Among forestry officials, 54.0% indicated that forestry officials aided Forest offences. It is recommended that Government should provide forestry officials with the necessary financial support, equipment, communication and transportation to enable them carry out their work promptly and efficiently. In addition, stiffer penalties should be meted out to forest offenders to serve as deterrent for others.

Keywords: Forest offences, illegal felling, forest stakeholders, sustainable forest management

INTRODUCTION

Sustainable forest management (SFM) has always been a goal of forestry sector in any country (Tropical Forest Update, 2005). Higman *et al* (2005), defines SFM as the best available practices based on current scientific and traditional knowledge, which allow multiple objectives and needs to be met without degrading the forest resource. In contrast, "bad forest management leads to loss of livelihoods, loss of cultural assets and knowledge, loss of an asset base for national development. Increased awareness of the magnitude and global implications of illegal activities in the forestry sector have triggered various initiatives to control them in both industrialized and developing countries. Efforts are being made at the local, national and international levels by various stakeholders to address the issue. Several governments are also in the process of rationalizing their legal and policy frameworks, building institutional capacity to foster better law compliance and gathering additional data on the extent and nature of illegal operations (FAO, 2005).

Nigeria has a land area of 923,772 km^2 (UNEP, 2006) and contains over 600 species of timber, significant numbers of aquatic birds and other rare mammals which attest to the abundance of the country's genetic resources, diversity of ecosystems and natural beauty (Olorode, 2002). At independence, Nigeria was richly endowed with forest resources enough to sustain the economies of the timber producing states. A combination of factors has however, put to question the ability to hitherto rich forest of the country to sustainably produce needed products to effectively bridge supply-demand gap. This gap has been created because of high increase in population and massive deforestation for other development activities (Enabor, 1986). Meanwhile, Forest Management Evaluating and Coordination Unit, FORMECU (1993) has put the average annual deforestation rate in Nigeria at 3.5 percent. The strategies for forest policy implementation in the South-west Nigeria are feeble and uncoordinated.

Much more importantly, there is dearth of information on the magnitude of forest offences, stakeholders' involvement in forest offences and the impacts of forest offences on the sustainable forest management in Nigeria. General reports on forest administration have revealed that annual occurrence of forest offences has for long been a forest management problem (CIFOR, 2003). It is disheartening to know that a permanent solution to this age long problem has not yet emerged.

Forest offences constitute an index of the inefficiency of forest service. For instance, illegal logging is a major problem for many timber-producing countries in the developing world. It causes environmental damage, costs governments billions of local currencies in lost revenue, promotes corruption, and undermines the rule of law and good governance (Palmer, 2001; Greenpeace, 1999). It also retards sustainable development in most of the producing countries. Many researchers have only indicated the destructive effects of forest offences in plantations and natural forests wildlife and their habits, but hardly quantified the magnitude of financial losses involved (FAO, 2001).

The damage caused by illegal activities and corrupt practices in the Nigerian forest is a problem of enormous proportions. Forest exploitation is dominated by rampant illegal harvesting, large scale violation of trade regulations both domestically and internationally, fraudulent practices, abetted or condoned by government officials and other destructive activities in violation of applicable laws. Based on the above, it is very pertinent that the assessment of forest offences among stakeholders and it implication on sustainable forest management be studied in South-west Nigeria with a view to recommending policy options for sustainable forest management.

METHODOLOGY

Study Area

The study was carried out in six states of South-west Nigeria; these include Lagos, Ogun, Oyo, Osun, Ondo and Ekiti States. The study area has 85 constituted Forest reserves with a forest area cover of 842,499 hectare.

Sampling of Forestry Stakeholders

The survey was conducted through the use of structured questionnaire and focus group discussions to gather relevant data from forest stakeholders in the selected States. The respondents were made up of forest officers, saw-millers, timber contractors, and people living within and around the forest reserves. One Officer in charge of each administrative zone was selected and 20 percent of forestry officials from each of the State headquarters; this gives a total of 152 officials. Ten percent of the registered timber contractors were randomly selected in each of the State across the zones. The samples were collected pro-rata, according to the population of the timber contractors in each zone. Thus, for the six states, 10 percent sampling yielded a total of 128 timber contractors. Ten percent of the registered saw-millers were randomly selected from each State across the zones. The number of saw-millers arrived at is presented was 201. A total of 251 dwellers in local communities located in selected forest reserves in each of the states were randomly sampled. These people constitute a major stakeholder because they live within the forest reserve and directly have impacts on the state of the forests.

RESULTS

Occurrences of Forest Offences in the Southwestern States of Nigeria

Table 1 showed the distribution of occurrences of forest offences among timber contractors and saw millers in south-west states of Nigeria. More than 70% of the saw millers and 75.8% of the timber contractors have committed forest offences before the survey. The state with the highest percent of occurrence of forest offences among saw millers was Osun State (85%) while the least was Ekiti State (55%) as shown in Table 1. However, Ekiti State (83.3%) had the highest occurrence of forest offence among timber contractors while the other states had more than 70% of occurrence of forest offence among the timber contractors with Ogun State (71%) having the least.

Table 1: Distribution of Respondents that Committed Forest Offences in the Last Five Years

	Saw miller						Timber Contractors					
	No		Yes		Total		No		Yes		Total	
State	**N**	**percent**	**N**	**percent**	**N**	**percent**	**N**	**percent**	**N**	**percent**	**N**	**percent**
Ekiti	9	45.0	11	55.0	20	100.0	3	16.7	15	83.3	18	100.0
Lagos	9	26.5	25	73.5	34	100.0	1	20.0	4	80.0	5	100.0
Ogun	12	27.3	32	72.7	44	100.0	9	29.0	22	71.0	31	100.0
Ondo	11	29.7	26	70.3	37	100.0	5	21.7	18	78.3	23	100.0
Osun	5	14.7	29	85.3	34	100.0	7	25.9	20	74.1	27	100.0
Oyo	13	40.6	19	59.4	32	100.0	6	25.0	18	75.0	24	100.0
Total	59	29.4	142	70.6	201	100.0	31	24.2	97	75.8	128	100.0

Common Forest Offences among Saw Millers and Timber Contractors in the Last Five Years

Across all the south-west states in Nigeria, as shown on Table 2, illegal felling of trees was the most common (97.2%) followed by failure to produce log certificates (94.4%), and felling of undersized trees (78.2%) while non-renewal of property hammer (14.1%) was the least common forestry offence among saw millers. All (100%) the saw millers in Oyo, Ogun, and Ondo States had committed illegal felling of trees in the last five years and all the saw millers in Ekiti State had committed failure to produce log certificates. Felling of undersized trees was most common in Ogun State (87.5%) and non-renewal of property hammer was most common among saw millers in Osun State (24.1%). Among timber contractors, illegal felling of trees (94.8%) was the most common forest offence followed by failure to produce log certificates (91.8%) and felling of undersized trees (74.2%) while non-renewal of property hammer (18.6%) was the least common forest offence among the timber contractors in southwest Nigeria. Lagos, Ogun, Ondo and Osun States had the highest illegal felling of trees (100%) and Lagos and Ondo States (100% each) had the highest failure to produce log certificates. Osun State (80%) had highest felling of undersized trees among the timber contractors and Lagos State with 25% of the contractors had highest rate of non-renewal of property hammer (Table 2).

Table 2: Distribution of Saw millers and Timber Contractors on the Forest Offences Committed in the Last Five Years

Forest offences	State													
	Ekiti		Lagos		Ogun		Ondo		Osun		Oyo		Total	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Saw millers														
Illegal felling	10	90.9	24	96.0	32	100.0	26	100.0	27	93.1	19	100.0	138	97.2
Failure to produce log certificates	11	100.0	24	96.0	30	93.8	25	96.2	27	93.1	17	89.5	134	94.4
Non-renewal of property hammer	2	18.2	2	8.0	3	9.4	3	11.5	7	24.1	3	15.8	20	14.1
Felling of undersized trees	7	63.6	19	76.0	28	87.5	20	76.9	23	79.3	14	73.7	111	78.2
Total*	11	100.0	25	100.0	32	100.0	26	100.0	29	100.0	19	100.0	142	100.0
Timber contractors														
Illegal felling	11	73.3	4	100.0	22	100.0	18	100.0	19	95.0	18	100.0	92	94.8
Failure to produce log certificates	14	93.3	4	100.0	17	77.3	18	100.0	19	95.0	17	94.4	89	91.8
Non-renewal of property hammer	4	26.7	1	25.0	4	18.2	3	16.7	3	15.0	3	16.7	18	18.6
Felling of undersized trees	10	66.7	3	75.0	17	77.3	14	77.8	16	80.0	12	66.7	72	74.2
Total*	15	100.0	4	100.0	22	100.0	18	100.0	20	100.0	18	100.0	97	100.0

*Totals are more than 100 percent because respondents could choose more than one option

Forest Offences among Rural Dwellers surrounding Forest Reserves

Figure 1 showed the percentage distribution of the perception of local farmers from southwest Nigeria about forest offences. In general, 72.5% of the farmers indicated that people commit forest offences while 27.5% believe that people do not commit forest offences. However, from each state, more than 70% of the farmers from Ogun (74%), Ondo (73%), Osun (75%), and Oyo (75%) states believe that farmers commit forest offences the highest perception of forest offences is in Lagos state (90%) but about 55% of farmers in Ekiti State believe that farmers committed forest offences.

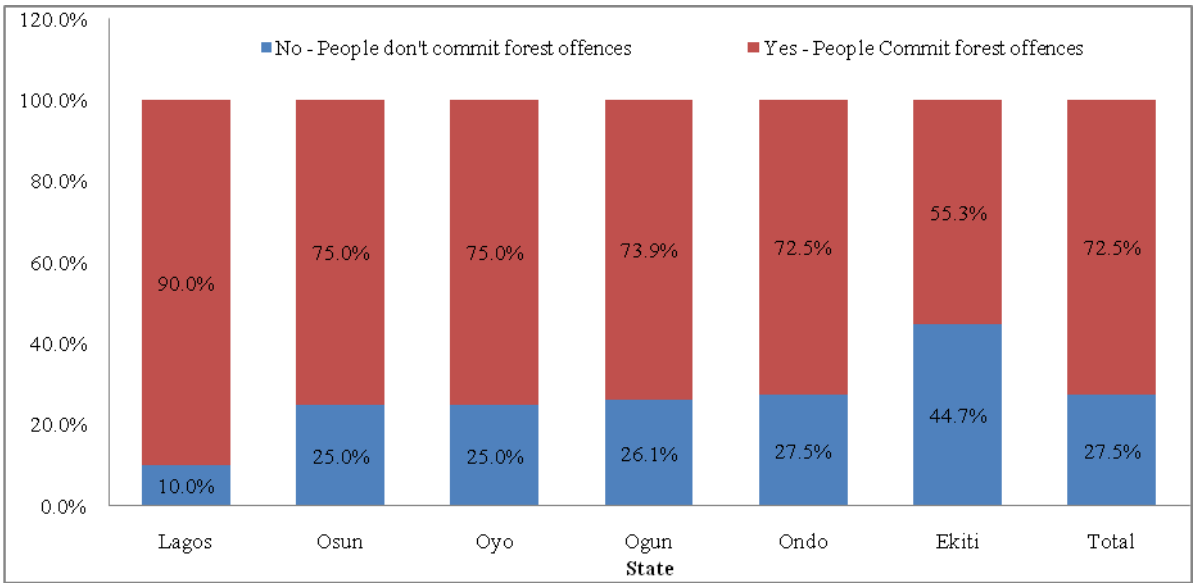


Figure 1: Perception of the farmers on the question of whether people commit forest offences or not

Common Forest Offences among the Rural Dwellers

Figure 2 showed the distribution of common forest offences among farmers in southwest Nigeria. Hunting in the forest reserve was the most common (79.7%) forest offence among the farmers followed by making firewood in reserve (76.9%) and clearing of tree species (70.1%). Other forest offences among the farmers included preference for *Gmelina* (63.3%) and more than 50% of the farmers also indicated erection of structures (53%) while about 20% of the farmers also indicated that planting tree species within the crops as a forest offence.

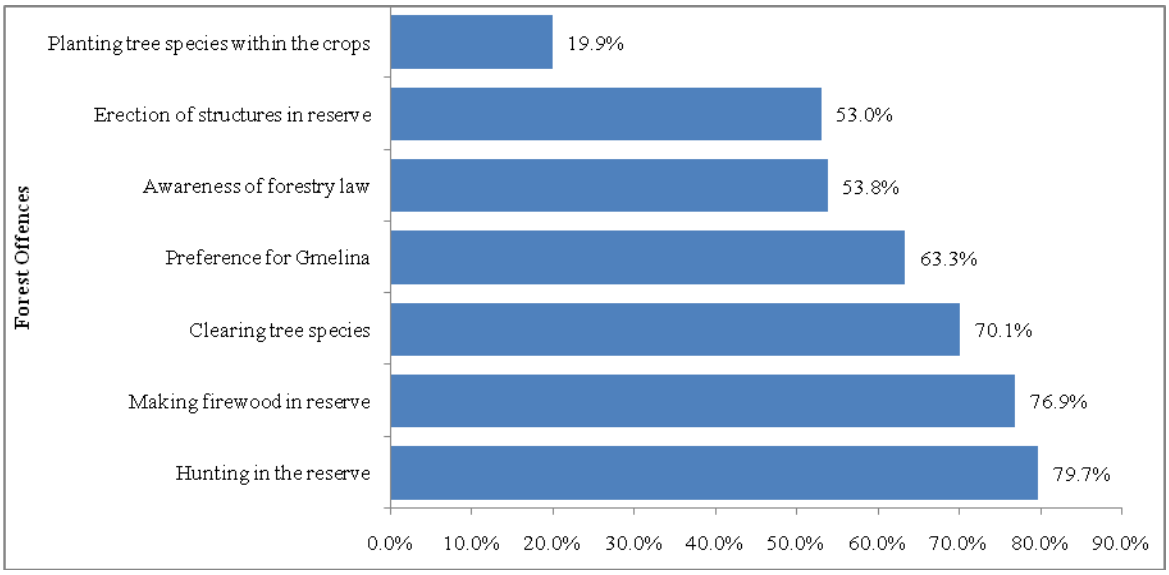


Figure 2: Common forest offences among farmers in South-west, Nigeria

Factors promoting Forest Offences as Indicated by Forestry Officials

Most of the officials, which were more than 80%, across all the states, indicated that weak penalty for offenders was the most common factor (Figure 3). This was followed by more than 76% that indicated that the fact that government tariffs being too high was another contributing factor to forest offences and this was highest in Oyo State (83%); also, insufficient supply to meet demand, which was the most pronounced in Lagos State (89%), was indicated by 71% of the officials across the states. Quite more than half of the respondents indicated that inefficient exploitation practices (59%), lack of efficient supervision (56%), and cumbersome administrative procedures (54%) were also factors that contribute to forest offences (Figure 3). The least mentioned factor was disputes over property rights between government and communities (37.4 %) and this was most mentioned in Osun State (48%) and least in Lagos State (22%).

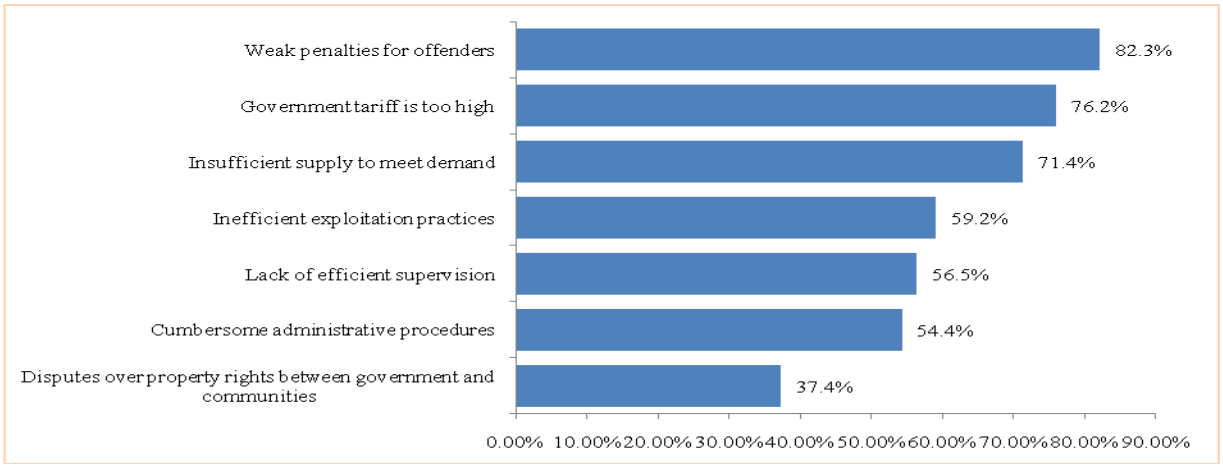


Figure 3: Percent distribution of the factors promoting forest offences as indicated by forestry officials in Southwest, Nigeria

Factors that Promote Forest Offences among Sawmillers

Insufficient supply to meet demand was the most common (84%) factor (more than 90% in Ogun, Ondo and Osun States), followed by weak penalties for offenders (82%) among factors that promote forest offences among saw millers. More than 70% of the respondents indicated that government tariffs being too high (77%), which was highest in Ekiti State (85%); lack of capital to finance business (76%) – this was highest in Lagos State (94%); and high cost of production (71%) were also factors that promote forest offences

among saw millers. Other forestry offences indicated by the saw millers included inefficient exploitation practices (62.7%; most common in Osun State, 79%), lack of efficient supervision (54.7%; most common in Lagos State, 62%), and cumbersome administrative procedures (49.8%; most common in Ogun State, 54%), while the least common factor that promotes forest offences was disputes over property rights between government and communities (36.8%), which was most common in Lagos State (41%) compared to other states (Figure 4).

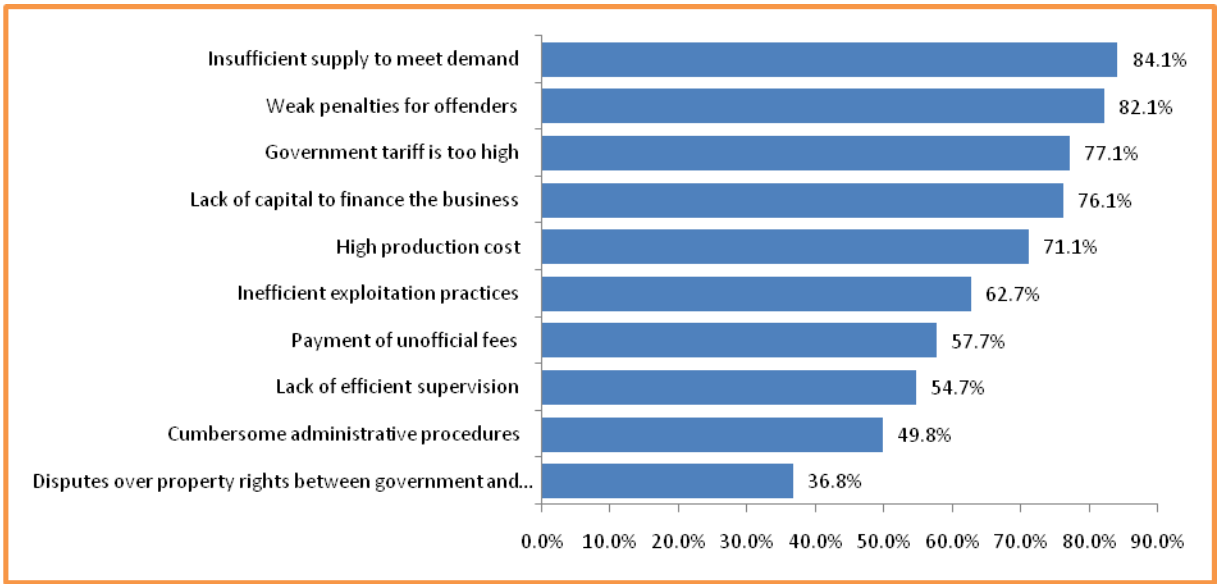


Figure 4: Factors that promote forest offences among sawmillers

Factors that Promote Forest Offences among Timber Contractors

Most of the respondents, which was more than 80% of the timber contractors across the south western states of Nigeria, indicated that insufficient supply to meet demand (84.4%; this was highest in Lagos State with 100%), weak penalties for offenders (82%; 100% in Lagos State), and high cost of production (80.5%; 100% in Lagos State) were the most common factors promoting forest offences among timber contractors. Furthermore, 75.8% of the timber contractors indicated that lack of capital to finance the business, which was 100% in Lagos State, and 71.9% indicated that government tariff being too high were also factors that promoted forest offences among the timber contractors. Other factors that promoted forest offences among timber contractors included payment of unofficial fees (61.7%), inefficient supervision (58.6%), inefficient exploitation practices (57%), cumbersome administrative procedures (51.6%), and the least pronounced, disputes over property rights between government and communities (38.3%) as shown on Figure 4.

Number of Years Operation in Reserve and Forest Offences among Timber Contractors

Table 3 shows the relationship between number of operating in reserve and forest offence among timber contractors in southwest Nigeria. Apart from those that had operated for five years or less among whom 75% had committed forest offence, there was an increase in the proportion of forest offence with increase in the number of years of operating in reserve. From about 70% among those that had spent 6-10 years the proportions increased to 100% among those that had spent 16-20 years and those that had spent 21 years or more. There was no significant relationship between number of years spent in forest reserve and forest offence ($p>0.05$).

Table 3: Relationship between number of years operating in reserve and forest offences in last five years among timber contractors in southwest Nigeria

Years operating in the reserve (Years)	Committed offence in the last five years				Total	
	No		Yes			
	N	percent	N	Percent	N	Percent
<= 5	9	25.0	27	75.0	36	100.0
6 – 10	19	30.6	43	69.4	62	100.0
11 – 15	3	11.1	24	88.9	27	100.0
16 – 20	0	0.0	1	100.0	1	100.0
21+	0	0.0	2	100.0	2	100.0
Total	31	24.2	97	75.8	128	100.0
Chi square value =	**4.893**	**df =**	**4**	**Sig. =**	**0.298**	

Number Years of Operation in Forest Reserve and Forest Offences among Sawmiller

Table 4 shows relationship between number of years operating in reserve and forest offences in last five years among saw millers in south-west, Nigeria. All (100%) the saw millers that had spent 21 years or more in their respective Reserve had committed forest offence in the last five years. About 73% of those had spent 6-10 years in reserve, 69% of those that had spent 5 years or less and 66% of those that had spent 11-15 years, as well as half of those that had spent 16-20 years in the forest reserve had committed forest offence in the last five years. There was no significant relationship between the age of the saw-millers and forestry offences in the last five years (p>0.05).

Table 4: Relationship between Number of Years of Operation in Forest Reserve and Forest Offences in the Last Five Years among Sawmillers in Southwestern Nigeria

Years operating in the reserve (Years)	Committed offence in the last five years				Total	
	No		Yes			
	N	percent	N	Percent	N	Percent
<= 5	13	31.0	29	69.0	42	100.0
6 – 10	30	26.8	82	73.2	112	100.0
11 – 15	14	34.1	27	65.9	41	100.0
16 – 20	2	50.0	2	50.0	4	100.0
21+	0	0.0	2	100.0	2	100.0
Total	59	29.4	142	70.6	201	100.0
Chi-square value = 2.515		**df = 4**		**Sig. = 0.642**		

DISCUSSION

From the results of the study, the dominant forest offences among saw-millers and timber contractors include illegal felling of trees, failure to produce log certificates, non-renewal of property hammer, and felling of undersized trees. Among the offences, illegal felling of trees was the most prominent that the stakeholders committed in the last five years. It was discovered that illegal felling of trees dovetailed to other forms of offences such as felling of undersized trees, avoidance of log certificates, non-renewal of property hammer. The issue was compounded by insufficient forestry officials (especially the boundary guards) on the field to prevent the illegal activities. Also, the forestry officials are not undergoing training and are not provided with appropriate and adequate logistics (equipment, machinery, vehicles and fund) to be able to fight the increasing level of forest offences. At the level of rural dweller, illegal felling of trees and illegal farming were identified as the most common forest offences. Increasing demand for wood resulting into insufficient supply of timber as well as high government tariff were indicated by the saw-millers and timber contractors as another factors promoting forest offences. The high tariff levied on the timber contractors could be a major reason their cost of production is too high and hence, they tend to commit forest offences to offset the costs. Other reasons for committing forest offences included lack

of capital to finance the business, avoiding payment of official fees, and inefficient exploitation practices by contractors and saw-millers; low level of job satisfaction by forestry officials; inadequate or lack of funds for forestry field activities; and untimely release of funds for effective forestry administration. Also, rural dwellers involve in illegal hunting which directly lead to arson by setting forest reserves on fires. Other identified forestry offences included hunting and fetching firewood in the reserve, clearing tree species, preference for *Gmelina* wood (Agera *et al*, 2009), non-awareness of forestry laws, erection of structures within the forestry reserve.

Above all, most common reason that forest offences are common is weak penalties and enforcement of forest laws. This was also discovered by Udo (1997) and Agera*et al.*(2009). In their fidnings, they argued that dearth of forestry legilation and corrupt practices by forestry staff were the major causes of deforestation. This implies that there is no adequate (if any) enforcement of forest law against offenders. Those apprehended eventually get away since it costs them very little to be released. Forest offences have huge economic implication on the nation. It was observed from the result that the number of offences keep increasing by the year, which implies that either the forestry policies that guide forest offences are not being implemented or more people are coming into the forestry business without adhering to the guidelines for exploitation of the timber resources.

CONCLUSION

Sustainable forest management in Nigeria has suffered serious setbacks due to illegal forest activities. A number of forestry offences were identified in South-west of Nigeria at the different levels of the stakeholders. This means that the illegal forest activities were carried out by majority the forest stakeholders. Saw-millers and Timber contractors directly involve in tree felling, therefore, responsible for highest level of forest offences. However, their activities are, in most cases, supported by the forest officials and in some cases rural dwellers.

The widespread violation of existing forest laws and regulation has major negative impacts on forests, livelihoods, revenue generation and the rule of law. Something must be done about that. However, reforming laws and regulations will have limited impact unless one also reforms the institutions in charge with implementing them. These institutions must have to become more efficient, outcome oriented, less corrupt and more transparent for any meaningful development to take place in forestry.

REFERENCES

Agera, S., Adegeye, A. and Jimoh, S.O (2009): Deforestation Trends in Forest Estates of Vandeikya Local Government of Benue State, Nigeria. Journal of Research in Forestry, Wildlife and Environment, 1 (1), 46-55. In: Kuemmerle, *et al.*(2009): Forest cover change and illegal logging in the Ukrainian Carpathians in the transition period from 1988 to 2007. Remote Sensing of Environment, 113 (2009), 1194-1207.

CIFOR (2003): Forest Law Enforcement and Rural Livelihoods; Analysis and Dissemination by the Centre for International Forestry Research with funding from DFID and PROFOR International Forestry Review, vol.5(3), 2003 Pg 1-8.

Enabor, E.E(1986): Social- Economic Factors of Deforestation in Nigeria: The challenge of Deforestation in Nigeria. Proceedings of 1986 Annual conference of Forestry Association of Nigeria, A.B. Oguntala Pp 111 – 125.

FAO (2001): A Reform of Fiscal Policies in the Context of National Forest Programmes in Africa.

FAO (2005): 'Best Practices for Improving Law Compliance in the Forest Sector' (Rome, Italy: FAO, 2005): Also see: 'Strengthening Forest Management in Indonesia through Land Tenure Reform'. www.foresttrends.org/documents/files/doc_107.pdf.

FORMECU (1993): Forest Revenue System Development in Nigeria. Proceedings of the Seminar on Forest Revenue System Development in Nigeria held in Benin city, Edo State 10 - 11 November, 1993 (ed. J.A. Okojie) Pp 4 – 9.

Greenpeace International (1999a): Buying destruction: A Greenpeace report for Corporate Consumers of forest products. Greenpeace International Amsterdam. Pp 16-17.

Higman, S., Mayers, J., Bass, S., Judd, N.&Nussbaum, R. (2005): The sustainable forestry handbook; a practical guide for tropical forest managers on implementing new standards, second edition. Earthscan London, UK. ISBN 1844071189.

Olorode, O. (2002): Vegetation and Fauna. In Africa Atlases.Nigeria Les Edition J. A. 57 bis, rue d' Auteuil 75016, Paris –France, October 2002 Pp 58.

Palmer, C.E (2001): The Extent and Causes of Illegal Logging: An Analysis of a Major Cause of Tropical Deforestation in Indonesia. CSERGE Working Paper, Economics Department University College London and Centre for Social and Economic Research on the Global Environment University College London and University of East Anglia.

Tropical Forest Update (2005): A newsletter from the International Tropical Timber Organization (ITTO).Vol 15. No 4. Pp 1-6.

Udo, E. S. (1997): Forest Offences and Impediment to Forest Resources Conservation in Akwa-Ibom State. In proceedings of the 25th Annual Conference of the forestry Association of Nigeria held in Ibadan Oyo state, Nigeria. 8-14pp

UNEP (2006): The United Nations Environment Programme, Nigeria Environmental Profile. Pp 1-12

Local Communities Perception and Participation in Conservation and Governance of Four National Parks in Nigeria

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ABSTRACT

Despite the fact that for a long time, many local communities contributed to the conservation and protection of biological resources; only recently has their importance in natural resources protection and the need for deriving benefits from protected areas has been recognized. Survey of the villages around four Nigerian Parks was carried out to determine the peoples' perception of purpose of establishment of Park and protection responsibility. Questionnaires were administered to elicit information from the villages around the four parks: Cross River (CRNP); Gashaka-Gumti (GGNP); Kainji Lake (KLNP) and Old Oyo (OONP) National Parks. All the respondents in CRNP (100%) and more than half of the respondent in GGNP (65.3%) and KLNP (63.9%) reported that the Park authorities only advocated for the non-intervention of the Park resources, while in OONP, 57.8% reported that the Park authority did request for their participation in the management of the Park. Majority of the respondents in CRNP (62.4%) indicated that the Park should be protected by the community because the land belongs to them and they live closer to the Park, while respondents in GGNP (46.2%) and KLNP (50.6%) indicated that the Park should be protected by the Government since the Park belongs to the Government. The outcome of the general regression analysis revealed that out of six variables considered, three variables (Religion, Occupation and Qualification) were significant at $p<0.01$. The issue of forest governance is an important aspect of the conservation which the people must be involved and hence the need to involve the people in the Management of the Protected areas.

Keywords: Local community, perception and participation, governance, protected areas

INTRODUCTION

As stated by Borrini-Feyerabend *et al.,* (2004) Protected areas represent the heart of the world's political and economic commitment to conserve biodiversity and other natural and related cultural resources. They are, therefore, a major component of official conservation policy and practice. On the basis of national returns, the United Nations Environment Programme's World Conservation Monitoring Centre (UNEP-WCMC) has recently calculated that there are more than 102,000 protected areas throughout the world. Taken together, they cover more than 11.5% of the terrestrial surface of the earth (though only 3.4% of the entire surface, since there are relatively few marine protected areas (Chape *et al.*, 2003). These sites have been established by virtually all countries of the world and are managed through special rules and for conservation goals. Conservation approaches, however, are evolving rapidly, responding to social and economic changes as well as advances in natural and social sciences.

Many rural communities surrounding the parks do regard forest and game reserve as belonging to the government. Analysis of the people's perception of the socio-economic pressure on forest resource use and management demonstrate that many people have no direct responsibility for the maintenance of the park because they don't belong to them and they are denied access to some of their traditional forest utilities. This denial perpetuates negative perception that many protected areas are actually a liability rather than asset. (Juan *et al.*, 2003). In Africa, with many conservation initiatives steadily moving away from colonial-rooted concepts that conservation cannot be practiced unless indigenous peoples are removed from natural resource areas, comes the recognition that conservation cannot be guaranteed in the long term without the support of local people (Cock & Koch, 1991; IIED, 1994). Conservation practitioners have became aware that 'problems faced by wildlife managers are more sociological than biological' (Kideghesho, 1999). Sustainable forest or protected areas governance is one of the major agenda items of international development and environmental debates. In context of the Forest Principles of UNCED's Agenda 21, global community and countries all over the

world have committed to take necessary measures for the management of forest resources to ensure the sustained availability of the goods, and environmental/social services provided by the forest and trees (FAO, 2001 and 2007). "Governance" has become an important term and been widely used in literature since 1990s. However it is generally used with different meanings depending on the context (Kitthananan 2006). The general concept of governance is defined as *"The institutions and processes used by rightholders and stakeholders to make and influence decisions, and to exercise authority and responsibility in society"* (Wilson 2002). Consequently, institutional changes in forest management paradigm have been made in many developing countries and participatory or joint forest management became major policy trend in the forestry sector and Protected area of most of the countries (Agrawal and Gupta, 2005; Nygren , 2005; Shahbaz *et al*., 2007). Involvement, it is argued, enhances co-operation, as co-operation is strongly influenced by the possibility of individuals having to deal with each other repeatedly (Berry *et al*., 1993; Putnam, 1993). In addition, identification with a group, association, or cause, elevates common interests (Lakoff, 1996), even if individuals' motives for membership are self-serving.

Participation encourages communities or groups to work together to achieve goals that are broader than those that can be achieved by individuals. Where citizens are jointly involved with elected representatives and managers this necessitates agreements for sharing responsibility and decision-making authority. Increasingly the concept of partnership is promoted, where organizations, agencies and citizens work together as equals (despite differences in power and resources) to achieve agreed objectives (Forgie *et al.*, 2001). One reason for this development is that the power of the traditional 'command and control' hierarchical government is being eroded by information and communications advancements (Clark and Reddy, 1999; Fukuyama, 1995; Thomas, 1995). Effective local participation between communities and government agencies provides a unique possibility for achieving long-term sustainability (Grumbine, 1994).

Local communities will not manage their forests in ways that provide for externalities, such as the global benefits of biodiversity or climate regulation, unless they are constrained by laws or provided with financial incentives (Sayer *et al*., 2005). The degree of success of CBNRM programmes relies on a number of key factors, summarized here: maintaining biological diversity and endangered species conservation; public sector support; private tenure of land and wildlife resources; community consultation, participation and ultimately self-management; that the benefits to involved local communities are greater than the cost of utilising natural resources through less sustainable means; a long term potential of incoming revenue to avoid reliance on donors and outsider investment; capacity building; and the stability of community institutions. (IIED,1994; Leader-Williams *et al*, 1996; Bourn & Blench, 1999).

However, linking conservation with poverty alleviation is more than effective national park management, but requires that issues of governance, human rights, equity and power are addressed at the highest levels (Fisher, 2008). The relationship between conservation and development cannot be ignored and protected area management has a fundamental role in sustainable development (Adams et al. 2004). By permitting the sustainable use of natural resources and involving the communities in the management process conservation projects can achieve better results and higher conservation impact in long term (Brooks *et al.*, 2006, Baral *et al.*, 2007). The study was therefore, carried out to determine the perception and level of participation of the Local people in conservation and governance of parks.

METHODOLOGY

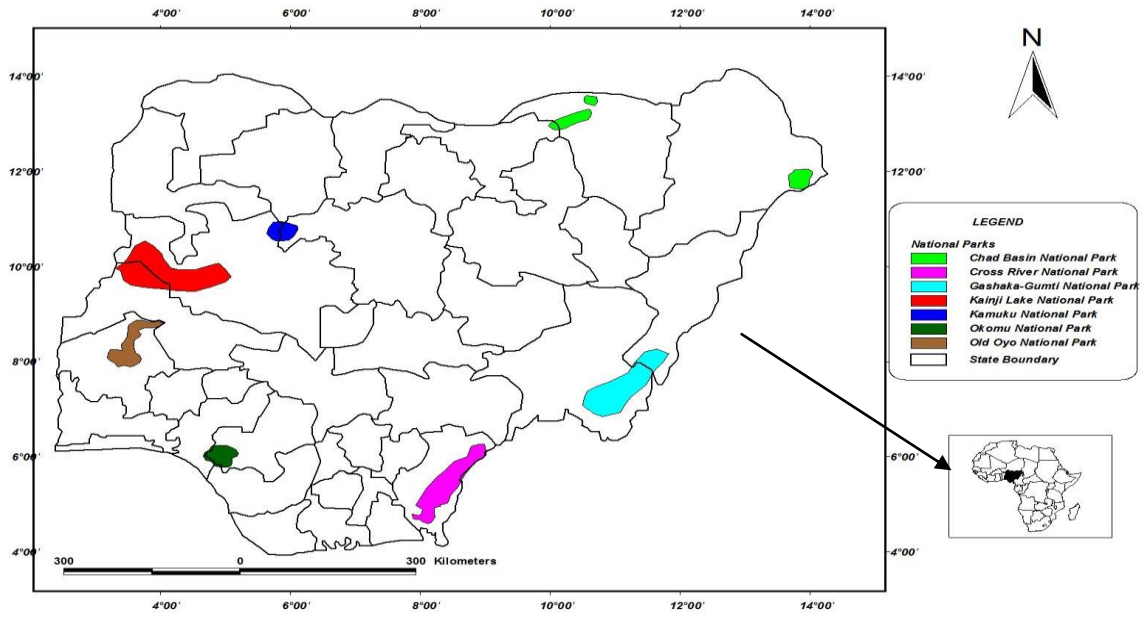
Study Area

The study was conducted in Cross River (CRNP), Gashaka-Gumti (GGNP), Kainji Lake (KLNP) and Old Oyo National Parks (OONP) (Maps 1, 2, 3, and 4).. The Nigeria National Parks are ecologically and culturally important areas where human habitation is largely disallowed and tourism is encouraged. Presently in Nigeria, there are currently seven (7) National Parks in different bio-geographic zones of the country. These are Chad Basin, Cross River, Gashaka Gumti, Kainji Lake, Kamuku, Old Oyo and Okomu National Parks. Together, the national parks cover about 22,592sqkm, which is about 2.5% of the country's land area of 923,768.64sqkm (Sofowora, 1993).

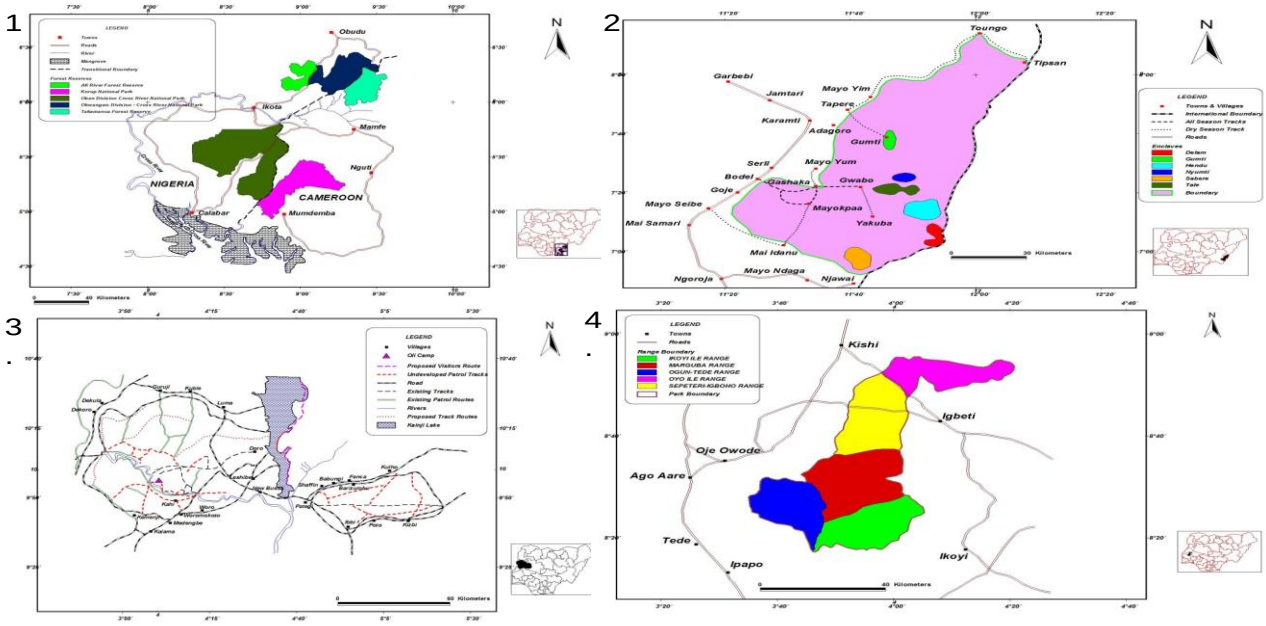
Sampling Technique

Primary data were collected from 109 local communities in support zone of four Nigeria National Parks. The study areas' selection was through multi-stage random sampling. The Parks were divided into Sector based on the Protection and administrative units of the Park. Sectors are further divided into ranges which are small units for Protection and conservation activities. Within the ranges are the support zone villages of the Parks that were selected for the study (Ogunjinmi *et al.*, 2014). Four parks were selected and sectors and ranges in the parks were sampled. Data were obtained through structured questionnaires administered to the Support Zone villages. Twenty percent of the communities in all the ranges of the Parks amounting to 109 villages were randomly selected from the list of communities lying between 0 – 10km from the Park boundaries. Questionnaires were administered to elicit information from the villages around the parks viz: Cross river: 20 villages; Mba, Bashu, Obung, Ojoor, Anape, Kejiuku, Okwa 1, Okwa 2, Okwango, Osomba, Abo Obisu, Okpazanga, Aking, Owai 1, Owai 2, Abu Mpang, Nsan, Botantong, Ifumkpa, Mpot (985 respondents); Gashaka:

22 villages; Mayo Bakari, Bam, Mayo Gbaggbag, Nasamu, Daga, Maiidanu, Lagaso, Mayo Birim andMayo Sangnare, Mayo Butali, Tipsan, Goje, Mayo Selbe, Gashaka, Chappal Hendu, Chappal Tale, Chappal Selgu, Chappal Nyumti, Filinga, Bodel, Sirip, Addagoro (1079 respondents); Kainji: 26 villages; Ibbi, Patiko 1, Patiko 2, Audu fari, Mulea, Aguan kaya, Kuble, Faje, Kamenji, Tenebo, Shafini kemberi, Shafini Libata, Tunga Wakili, Tunga Yakubu, Tunga Maje, Tunga Nailo, Kpellegi, Fanga, Kulho, Mazakuka, Woromakoto, Kali Mariga, Woro, Malale, Doro, Luma Baare (1134 respondents) and Oyo: 32 villages; Ibudo Baruba, Aloba, Yarima, Gida Olalere, Lasi, Tede, Budo Sango, Alakuko, Oke Owu, Bamgbose, Alarode, Sooro, Kosigi, Orisumbare Arogbe, Onile aro, Alada, Budo Ayinla, Ibudo Igboho, Ogundiran, Opa, Aba Nla, Alahusa, Abule Markurdi, Elerin, Alapata, Aba Ijesha, Imodi, Yawota, Oloka, Lube, Igboburo, Akinpeju (1013 respondents). The data gathered were presented and analyzed using descriptive statistics such as tables, percentages and regression analysis.



Map of Nigeria showing the Seven (7) National Parks



Maps of 1.Cross River, 2.Gashaka Gumti, 3. Kainji Lake and 4. Old Oyo National Parks

RESULTS

Demographic Characteristics of Respondents

Respondent's socio-cultural and economic activities revealed that there were more male respondents interviewed than the females in the park. In CRNP 75.43% of the respondents were male, 71.08 in GGNP, 65.96% in KLNP and 76.01% in OONP (Table 1). Most of the respondents were in the age group 15 – 25 in all the parks and it is slightly higher in KLNP (35.45%) and GGNP (34.20%) while it is lower in OONP (30.0%) and CRNP (28.48%) (Table1). Almost all the respondents in CRNP were Christians (99.98%) and traditional worshippers (0.10%). In GGNP and KLNP majority of the respondents were Muslims (82.38% and 98.33% respectively). In OONP 54.10% were Christians (Table 1). In addition, 79.09% in CRNP were married, GGNP (67.19%), KLNP (73.82%) and OONP (67.33%).The respondents were married in High incidence of polygamy was recorded in GGNP (43.29%) and KLNP (45.65%) and CRNP (29.68%) and OONP (28.20%) recorded low incidence of polygamy (Table 1). In terms of educational qualification all the parks have higher percentages of respondents with non- formal education. CRNP recorded 40.3% of respondent without formal education, GGNP (48.5%), KLNP (52.8%) and OONP (54.2%).

Respondents Perception about the Park

All the respondents in CRNP and more than half of the respondent in GGNP (65.3%) and KLNP (63.9%) reported that the Park authorities only advocated for the non-intervention of the Park resources, while in OONP 57.8% reported that the Park authority did request for their participation in the management of the Park. The views of the respondent varied in terms of protection responsibility of the Park. Majority of the respondents in CRNP (62.4%) indicated that the Park should be protected by the community because the land belongs to them and they live closer to the Park.

The respondents in GGNP (46.2%) and KLNP (50.6%) indicated that the Park should be protected by the Government since the Park belongs to the Government, and they have the human and other resources to protect the Park and also employed the Rangers for that reason. The views of the respondents in OONP however, differ because 78.4% of the respondents indicated that the protection of Park should be the joint responsibility of the Government and the community (Table 2). The outcome of the general regression analysis is shown in Table 3.

Table 1: Demographic Characteristics of Respondents

Park		CRNP 985 (%)	GGNP 1079 (%)	KLNP 1134 (%)	OONP 1013 (%)
Sex	Male	743 (75.43)	767(71.08)	748(65.96)	770(76.01)
	Female	242 (24.57)	312(28.92)	386(34.04)	243(23.99)
Age	15-25	282(28.48)	369(34.20)	402(35.45)	303(30.0)
	26-35	178(17.98)	170(15.76)	245(21.61	146(14.46)
	36 45	169(17.07)	174(16.13)	150(13.23)	158(15.64)
	46-55	129(13.03)	167(15.48)	175(14.43)	152(15.05)
	56-65	109(11.01)	111(10.29)	97(8.55)	90(8.91)
	66 Above	118(11.92)	88(8.16)	65(5.7)	164 (16.2)
Religion	Christianity	984(99.98)	126(11.68)	19(1.68)	548 (54.10)
	Muslim	0 (0)	889 (82.39)	1115 (98.33)	450 (44.42)
	Traditional	1(0.10)	6 (5.93)	0 (0)	15 (1.48)
Marital status	Single	170(17.26)	338(31.33)	295(26.02)	312 (30.80)
	Married	779(79.09)	725(67.19)	837 (73.82)	682 (67.33)
	Divorce	2(0.20)	6 (0.56)	0 (0)	6 (0.59)
	Widow	34 (3.45)	10 (0.93)	2 (0.18)	13 (1.28)
Numbers of wives					
	(1)	474 (70.32)	338 (56.71)	362 (54.35)	420 (71.80)
	(2-5)	179 (29.68)	258 (43.29)	304 (45.65)	165 (28.20)
Education	Non formal	397 (40.30)	523 (48.48)	599 (52.83)	549(54.19)
	Islamic	2 (0.20)	115 (10.66)	174 (15.35)	59 (5.82)
	Primary	263 (26.70)	255 (23.64)	152 (13.41)	185 (18.26)

	Secondary	252 (25.58)	168 (15.57)	169 (14.91)	183 (18.06)
	Tertiary	62 (6.29)	18 (1.67)	34 (3.00)	37 (3.65)
	Others	9 (0.91)	0 (0)	6 (0.53)	0 (0)
Occupation	Farmer	935(94.92)	991(91.84)	927(81.74)	721 (71.18)
	Trader	1 (0.10)	5 (0.46)	131(11.55)	37 (3.65)
	Fishermen	3 (0.31)	16 (1.48)	31(2.73)	28 (2.76)
	Civil servant	41 (4.16)	23(2.13)	30(2.65)	23 (2.27)
	Hunter	1 (0.10)	24 (2.22)	15(1.32)	63 (6.22)
	Others	5 (0.51)	20 (1.85)	130 (12.83)	11 (1.09)

The result revealed that out of six variables considered. Three variable were significant at $p<0.01$ in the linear function. Religion, Occupation and Qualification were significant at $p<0.01$. It means Religion, Occupation and Qualification of respondents were the factors that contributed to participation in conservation issues.

Local People Participation in Park Management

The respondents were asked if they participated in the management of the Park. More than half of the respondents in CRNP and KLNP stated that they participated in the management of the Park (54.0%) and 63.8%, respectively while 51.3% and 83.1% of the respondents in GGNP and OONP respectively indicated that they did not participate in the management of the Park. The respondents were further asked of the ways they participated in the management of the park. Majority of the respondents in CRNP (46.2%) and KLNP (61.8%) indicated that they hold meetings with Park officials (Table 4).

Table 2: Respondents' Perception about the Park

	CRNP	GGNP	KLNP	OONP
Park size				
Too big	952 (96.7)	1079 (100)	1120 (98.8)	1013 (100)
Adequate	7 (0.7)	0 (0)	4 (0.4)	0 (0)
No response	25 (2.5)	0 (0)	10 (0.9)	0 (0)
Park advocation				
Participation	0 (0)	374 (34.7)	385 (34.0)	586 (57.8)
Non intervention	984 (100)	705 (65.3)	725 (63.9)	427 (42.2)
No response	0 (0)	0 (0)	24 (2.1)	0 (0)
Protection responsibility				
Govt.	246 (25.0)	498 (46.2)	574 (50.6)	83 (8.2)
Community	614 (62.4)	316 (29.3)	187 (16.5)	136 (13.4)
Individuals	0 (0)	0 (0)	4 (0.4)	0 (0)
Govt. and community	124 (12.6)	265 (24.6)	373 (32.8)	794 (78.4)
Total	984	1079	1134	1013

Figures in parenthesis are in percentages
***** - Multiple responses

Table 3: Regression Analysis of Social-Economic Factors Contribution to Participation on Conservation issues

Model	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
(Constant)	1.667	.054		30.716	.000
Sex	.042	.017	.037	2.450***	.014
Religion	-.079	.015	-.081	-5.198***	.000
Marital status	-.032	.016	-.032	-1.999*	.046

Occupation	.042	.004	.155	9.988***	.000
Qualification	-.036	.006	-.093	-5.705***	.000

***Significant level 0.01
R^2 value = 3.6%
r = 0.191[a]
Adjusted R = 35 %
F-value = 31.71

Table 4: Local Peoples' Participation in Park Management

	CRNP (985)	GGNP (1079)	KLNP (1134)	OONP (1012)
Participation				
Yes	532 (54.0)	505 (46.8)	723 (63.8)	171 (16.9)
No	453 (46.0)	554 (51.3)	409 (36.1)	841 (83.1)
No Response	0 (0)	20 (1.9)	2 (0.2)	0 (0)
Total	985	1079	1134	1012
Types of Participation				
Meeting	455 (46.2)	230 (21.3)	701 (61.8)	142 (14.0)
Arresting poachers	54 (5.5)	10 (0.93)	0 (0)	0 (0)
Decision making	0 (0)	0 (0)	0 (0)	29 (2.87)
Total	532	482	723	171

DISCUSION

An aspect that reflects the local people's perception about the park is related to the size of the park. It is surprising to note that almost all the respondents believed that the parks are too big; hence, there is a need to reduce them by allocating part of the Parks as farmlands to the villagers. This perception reflects the reason why there was high rate of encroachment into the parks. Majority of the people in CRNP, GGNP and KLNP stated that the park only advocates for the non-intervention of "their" park, while people in OONP stated that park usually request for their participation. The view of the people varied in terms of protection responsibility of the park, majority of the people in CRNP stated that the park should be protected by the community because the land belongs to them and they live closer to the park. The people in GGNP and KLNP, however, believed that since the park belongs to the government, and they have the resources and the manpower (Rangers) to protect it, it should therefore be the responsibility of the government. The views of the people in OONP, however, differ, because they believed the protection of the park should be the dual responsibility of the government and the Community, because it takes the cooperation of the two parties to effectively protect the natural resources.

The observation is in line with that of Juan *et al (*2003) which stated that many rural communities surrounding the parks do regard them as belonging to the government. Analysis of people's perception of the socio – economic pressure on forest resource use and management demonstrate that many people have no direct responsibility for the maintenance of the park because it doesn't belong to them and they are denied access to some of their traditional forest utilities. This denial of access and use perpetuates negative perception many protected areas are actually a liability rather than asset. There is, therefore, need to change the perception of the local people that the park does not belong to them and that the protection responsibility is the sole responsibility of the government.

Accordingly, Bromley (1994) stated that the people are usually proactive in protecting things of value to them. It is in this context that biodiversity conservation initiatives have to be understood. Community-based conservation seems compelling because it starts from the most fundamental principle; that individuals will take care of those things in which they have a long-run sustained interest. The result of the regression analysis shows that the contribution of dependent variables is very low from r^2 value of 3.6%. Socio-economic factors influence on the determination of participation in conservation issues. The people's participation in the management of the park seemed to be at a passive level. Some of the respondents indicated they participated in park management through holding stakeholders meetings. While majority of the respondents indicated that they do not participate in park management. They also indicated that they were usually informed of the management decision. The need to involve the local people in conservation cannot be over-emphasized. Madulu (1999) stated that community participation can also be in the form of involvement in afforestation programs, provision of environmental education, and through sharing the benefits of the game reserve by financing some of the social service programs like education, health, water, and transport in the adjacent villages. Conservation cannot be imposed from above.

Any conservation effort must involve the local people, based on their interests' skills, self reliance traditions and it must initiate programs that offer them spiritual and economic benefits (Schaller, 1993).

CONCLUSION

The participation of the local people in all the parks is also very low. Most of the villagers believed that the parks belong to the government, which shows a poor perception about the park. This shows that the people are not well informed about the park and the collective responsibility of protecting the parks. There is therefore, the need to get the local people to be more involved in the conservation and governance of the Park.

REFERENCES

Adams, W.M. et al., 2004. Biodiversity conservation and the eradication of poverty. *Science (New York, N.Y.)*, 306(5699), pp.1146–9.

Agrawal, A. and K. Gupta (2005). Decentralization and participation: the governance of common-pool resources in Nepal's Terai. World Development, 33(7): 1101-1114

Baral, N., Stern, M.J. & Heinen, J.T., 2007. Integrated conservation and development project life cycles in the Annapurna Conservation Area, Nepal: Is development overpowering conservation? *Biodiversity and Conservation*, 16(10), pp.2903–2917.

Berry, J.; Portney, K.; Thomson, K. 1993: *The Rebirth of Urban Democracy.*Brookings Institution, Washington DC.

Bourn, D., & Blench, R., (eds) (1999) *Can Livestock and Wildlife Co-Exist?: An Interdisciplinary Approach* Oxford: Overseas Development Institute

Borrini-Feyerabend, G. 2004. "Gover nance of protected areas, participa tion and equity'' in Secretariat of the Convention on Biological Diversity (SCBD), *Biodiversity Issues for Consideration in the Planning, Establishment and Management of Protected Area Sites and Networks*. SCBD, Montreal, Canada

Brooks, T.M. et al., 2006. Global biodiversity conservation priorities. *Science (New York, N.Y.)*, 313(5783), pp.58–61.

Chape, S., Blyth, S., Fish, L., Fox, P. and Spalding, M. 2003. *2003 United Nations List of Protected Areas*. IUCN, Gland, Switzerland and Cambridge, UK and UNEP World Conser vation Moni toring Centre, Cambridge, UK.

Clark, M. and Reddy, P. 1999. *Towards Collaborative Governance: People-Centred Governance for the New Millennium*. Conference on Globalisation and People-Centred Development: a Local Government Response.

Cock, J., & Koch, E., (eds) (1991) *Going Green: People, Politics and the Environment in South Africa* Oxford: Oxford University Press. Chapter 15

FAO (2001). State of world forests. Food and Agriculture Organization FAO, Rome.

FAO (2007). State of the world's forests. Food and Agriculture Organization of the UNO. Rome, Italy.

Fisher, R., Magginis, S., Jackson, W., Barrow, E. and Jeanrenaud, S., 2008. *Linking Conservation and Poverty Reduction: Landscapes, People and Power*, Earthscan.

Forgie, V.; Horsley, P. and Johnston, J. 2001. Facilitating community-based Conservation initiatives.*Science for Conservation 169*. 76 p.

Fukuyama, F. 1995. *The Social Virtues and the Creation of Prosperity.* The Free Press, New York. Pg 24.

Grumbine, R.E.(ed.) 1994. *Environmental Policy and Biodiversity.* Island Press, Washington DC. Pg 298-299.

IIED (1994) *Whose Eden?: An Overview of Community Approaches to Wildlife Management*. UK: International Institute for Environment and Development

Juan Carlos Castro Herna'ndez, Rigoberto Herna'ndez Janapa, Sonia N'anez Jimenez,

Salvador Rodriguez Alca'zar, Carlos Tejeda Cruz, Alexser Vazquez Vazauez, Kim Batchelder, Alba Zoraida Maldonado Fonseca 2003. Community-based Conservation, Participatory Conservation in Buffer zone Communities in the Natural Protected Areas of Chiapas, Mexico.

Kideghesho, J.R., (1999) 'Conflict Management in Protected Areas' in *Kakakuona*: Tanzania Wildlife Magazine. No. 12, February to April 1999

Kitthananan, A., 2006. Conceptualizing Governance : A Review. *Journal of Societal & Social Policy*, 5(3), pp.1–19.

Lakoff, S. 1996: *Democracy – History, Theory and Practice.* Westview Press, Boulder, Colorado.

Leader-Williams, N., Kayers, J.A. & Overton, G.L., (eds) (1996) *Community Based Conservation in Tanzania* UK: IUCN Species Survival Commission

Madulu, N. F. 1999. Environmental degradation and marital fertility changes in Tanzania :the case study of Kondoa District, PhD thesis ,University of Dares Salam.

Nygren, A. (2005). Community-based forest management within the context of institutional decentralization in Honduras. World development, 33(4): 639–655.

Ogunjinmi, A.A**.;** Aiyeloja, A.A.; Osunsina, I.O.O. and Ogunjinmi, K.O. 2014. Understanding perceptions of protected areas management in developing countries: A case of Nigeria National Parks, *Global Environment***,** 7: 610-628

Osunsina, I.O.O. 2010. Anthropomorphic Dimensions of Biodiversity Conservation in some Nigeria National Park, Nigeria. (Unpublished Ph.D Thesis, University of Agriculture, Abeokuta).Pp 369.
Putnam, R. 1993: *Making Democracy Work: Civic Traditions in Modern Italy.* Princeton University Press, Princeton, New Jersey.
Sayer, J. A., Elliot, C., Barrow, E., Gretzinger, S.,Maginnis, S.,McShane, T. and Shepherd, G. (2005) The implications for biodiversity conservation of decentralized forest management, in J. A. Colfer and D.Capistrano (eds), The Politics of Decentralization; Forests, Power and People (London: Earthscan).
Shahbaz, B., T. Ali and A. Suleri (2007). A critical analysis of forest policies of Pakistan: implications for sustainable livelihoods. Mitigation and Adaptation Strategies of Global Change, 12(4): 441-453
Schaller, G. B, 1993, The Last Panda. University of Chicago Press and London, pp 312
Sofowora, A. 1993. *Non-wood forest products in Nigeria,* FAO Corporate Document Repository Pp. 6-7.
Thomas, J. 1995: *Public Participation in Public Decisions.* Jossey Bass Publishers, San Francisco. Pg 6, 59, 180.
Wilson, R., 2002. *Private Partners and The Public Good*, Belfast. Available at: https://www.belfastfestival.com/schools/SchoolofLaw/Research/InstituteofGovernance/Publications/briefingpapers/Filetoupload,47662,en.pdf.

SUB-THEME 5



Issues on Tropical Inventory, Measurements and GIS

Assessment of Land Cover Changes and its Carbon Stock in Omo Biosphere Reserve, Nigeria

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ABSTRACT

The study presents the methodology applied for estimation of forest woody biomass and its carbon content according to main tree parameters on the forest stand scale. Tree samples were collected at the Omo Biosphere Reserve, Nigeria. Twenty-three sample plots of tree species greater than 20cm at DBH and their heights were collected respectively. Ground-based and remote sensing measurements of trees attributes were converted into carbon estimates using allometric relationship and also remote sensing measurement using soil adjusted vegetation index (SAVI). Three classifications were made, namely; dense forest, light forest, and water. In Omo Biosphere Reserve, the land cover (thick forest) decreased from 78,882 ha to 73,863 ha, that is 60.4 percent to 56.6 percent for a period of thirteen years. The probability/transition matrix that dense forest would change to light forest was 0.4543. The accuracy level and Cohen's Kappa estimate of Omo Biosphere Reserve were 92 percent and K = 85.34% respectively. The estimate of AGB was 10,412.92metric tons/ha. The carbon-dioxide sequestered was 8,050,767.09tCO_2-e ha-^{1}, and the carbon-dioxide emitted was found to be 38,215.41tCO_2-e ha-^{1}. The regression analysis showed that CO_2 sequestered and CO_2 emitted had a correlation of determination which was R^2=0.8473. In conclusion, this study considered the environmental, economic and political values of woody biomass estimation of country forest biomass resources. The estimation is important for strategic planning of the use of forest resources. It then becomes expedient to apply adaptation measure, substantial planting of trees, and urgent development of forest and game reserves to mitigate environmental hazard.

Keywords: Biomass, allometric, transition matrix, game reserves

INTRODUCTION

In support of REDD, the Intergovernmental Panel on Climate Change (IPCC, 2006) provided guidelines to assist countries in developing carbon assessment methodologies. There is a need to first understand what forest cover (and therefore biomass) change is taking place in order to calculate baselines for any carbon credits or ecosystem services payments. It is important to provide reliable data on the spatiotemporal variation of aboveground biomass (AGB) in tropical forests. Mapping and monitoring carbon stocks in forested regions of the world, particularly the tropics, has attracted a great deal of attention in recent years as deforestation and forest degradation account for up to 30 percent of anthropogenic carbon emissions, and are now included in climate change negotiations. This is true not only in terms of improving estimates of carbon stored in forests for the emerging carbon markets, by providing spatially explicit information on the location of carbon stocks, but also with respect to avoiding the ambiguities, uncertainties and outright differences among land cover type classifications. Tropical forests play a very significant role in mitigating global climate change. They hold importance in ecosystems. Forests are estimated to sequestrate about 15% of global carbon emissions, global deforestation and forest degradation accounts for up to 20% of annual greenhouse gas emissions (Achard *et al*. 2007; Angelsen, 2008). There has been significant progress on climate change mitigation options, such as the REDD-plus scheme (Reducing Emissions from Deforestation and Forest Degradation in Developing Countries). Estimating above ground biomass (AGB) is still a challenging task in tropical and sub-tropical area which has biophysical environment (Lu, 2005). According to (Sierra *et al.*, 2007) detailed ground-based quantifications of carbon stocks are still few. The specific objectives were to evaluate land use land cover changes in Omo Biosphere Reserve, Nigeria between 2002 and 2015 and to determine carbon sequestration, stock estimation and storage capacity of trees.

MATERIALS AND METHODOLOGY

Omo Biosphere Reserve

Omo Forest Reserve is located between 6° 35' to 7° 05'N and 4° 19' to 4° 40'E in the South-West of Nigeria, about 135 km North-East of Lagos and 80 km East of Ijebu-Ode. It covers an area of about 130,500 hectares. Abeku sector is located in the north-eastern end of Omo forest reserve. The study was conducted in Queen's forest located within Omo Forest Reserve, with its core area (Omo Biosphere Reserve) of buffer zone 14,200 ha, was constituted a Strict Nature Reserve in 1949 and Biosphere Reserve in 1977 (Isichei 1995, Were 2001). The map is shown in the figure 1below.

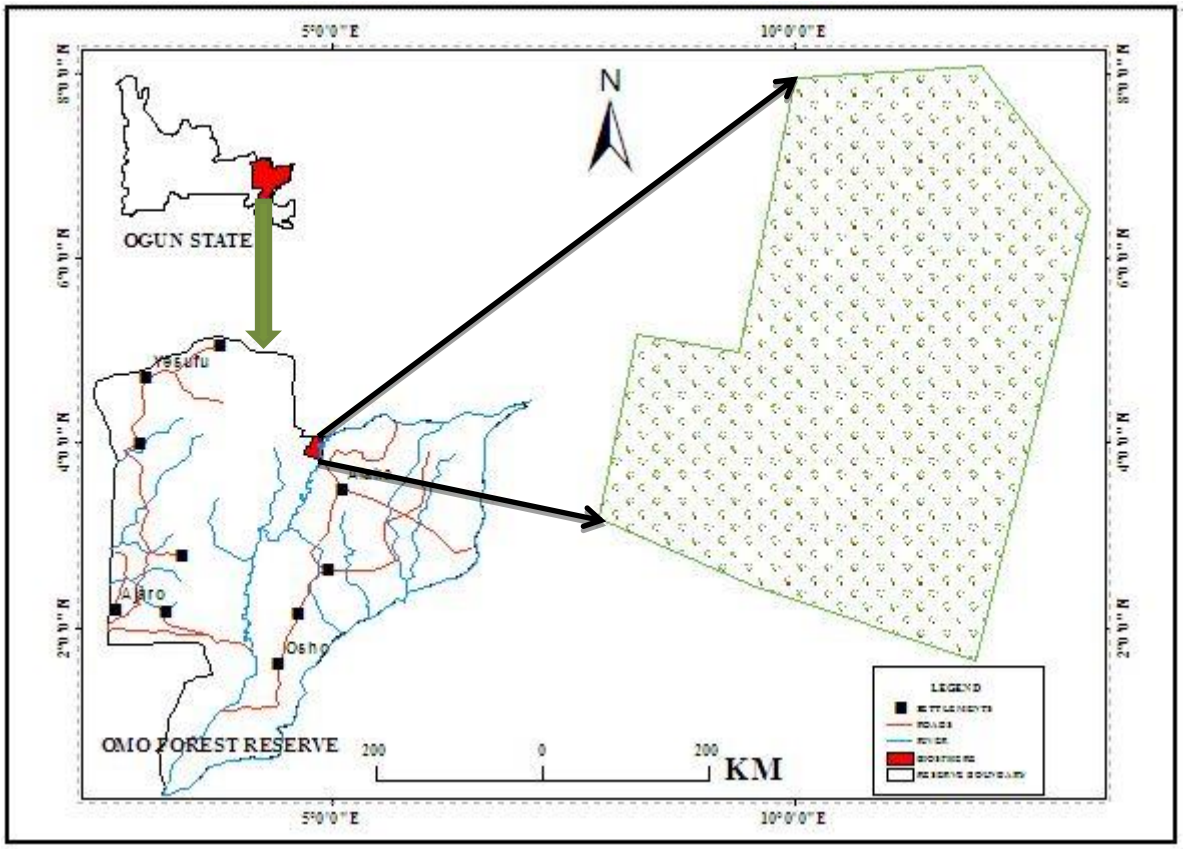


Figure 1: Omo Biosphere Reserve, Nigeria

Grid-Based Analysis of Sequestered Carbon

A grid-based analysis of sequestered carbon was done using GIS. This involves using interval method. The carbon index of each land use and sample plots was calculated. In this index, each raster was spatially assigned a carbon density index depending on land use and sample plots in GIS with 3om grid size. Using the raster calculator in ArcGIS, the pixels that fall in some land cover categories were assigned the value one (1), and a zero (0) everywhere else. Carbon index for each pixel were extracted, therefore, carbon sequestration map was developed.

Software

The software used are itemized below with their uses
1. ArcGIS 10.1 for GIS analysis
2. Erdas Imagine 2010 for image processing and remote sensing application
3. Statistical analysis
4. Microsoft excel

Field Equipment

1. GPS for navigation
2. Diameter tape for diameter measurement
3. Relascope for height measurement
4. Measuring tape for plot radius

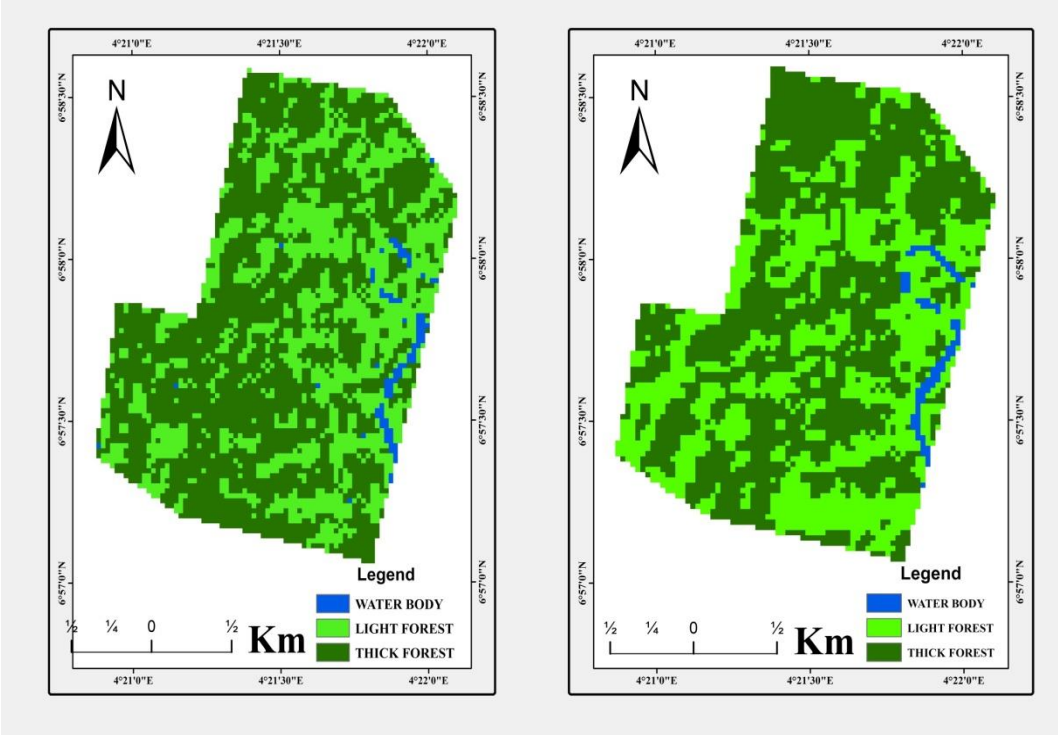
Key parameters to measure include:

1. Tree stem diameter at breast height (DBH)
2. Height

RESULTS

Land use/cover classification of Omo Biosphere Reserve, Nigeria

The supervised classification of the area produced two land use/cover maps from both landsat TM 2002 and landsat ETM 2015 imageries. The classification produced three categories of land use/cover namely; water body, light forest and thick forest as described and shown in figure 2 and table 1 below respectively.



(2002) (2015)

Figure 2: Land cover changes of Omo Biosphere Reserve, Nigeria for 2002 and 2015

Table 1: Percent area of land cover in Omo Biosphere Reserve, Nigeria

SNo.	Categories	2002 (%)	2015 (%)	2002 (ha)	2015 (ha)	Change/difference (ha)
1.	Water body	2.2	1.6	2871.0	2088.0	-783.00
2.	Light forest	37.4	41.8	48,807.0	54,549.0	5,742.00
3.	Thick forest	60.4	56.6	78,882.0	73,863.0	-5,019.0
	Total	**100.0**	**100.0**	**130,500.0**	**130,500.0**	

Table 2: Transition matrix of Omo Biosphere Reserve, Nigeria

CATEGORIES	Water-body	Light-forest	Thick-forest
Water Body	0.0286	0.3429	0.6286
Light forest	0.0181	0.4361	0.5458
Thick forest	0.0232	0.4542	0.5227

Table 3: Error Matrix of Omo Biosphere Reserve, Nigeria

	Water body (1)	Light forest (2)	Thick forest (3)	TOTAL
Water body (1)	*a*	*B*	*c*	***d***
	1	1	0	**2**
Light forest (2)	*e*	*F*	*g*	***h***
	0	**22**	1	**23**
Thick forest (3)	*i*	*J*	*k*	***l***
	2	0	**23**	**25**
TOTAL	***m***	***N***	***o***	***p***
	3	**23**	**24**	**46**

To calculate product matrix based on chance:

Product matrix
Cumulative sum of product matrix

The product matrix is the sum of the diagonals: 6 + 529 + 600 = 1135
The cumulative sum is: 6 + 46 + 48 + 69 + 529 + 552 + 75 + 575 +600 = 2500
So, expected is 1135/2500 = 0.454% or 45.4%

$$K = \frac{0.92 - 0.454}{1 - 0.454} = \frac{0.466}{0.546} = 0.8534$$

K = 85.34%

The result indicated that classification is 85.34% better than would have occurred strictly by chance.

Table 4: Carbon-dioxide sequestered and emitted in metric tons per hectare in Omo Biosphere Reserve, Nigeria

Plots	CO_2 Sequestered	CO_2 emitted if forest is burnt or deforested
1	124,299.29	806.92
2	201,586.76	1,248.28
3	713,085.79	4,799.32
4	285,741.42	1,298.76
5	160,941.04	932.39
6	485,212.29	1,895.63
7	266,464.42	1,641.49
8	676,844.83	2,921.15
9	196,859.09	921.82
10	440,953.28	1,667.81
11	362,029.10	1,509.67
12	173,990.41	672.33
13	239,336.03	1,221.37
14	286,305.14	1,274.91
15	246,939.96	1,292.78
16	164,949.28	1,059.99
17	238,586.04	1,155.96
18	123,609.26	945.65
19	446,045.32	1,901.57
20	130,872.77	422.27
21	404,662.11	1,282.54
22	927,496.89	4,598.48
23	753,956.57	2,744.32

Table 5: Regression analysis between CO_2 sequestered and emitted in Omo Biosphere Reserve, Nigeria

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.92048
R Square	0.84728
Adjusted R Square	0.84001
Standard Error	449.192
Observations	23

ANOVA

	Df	*SS*	*MS*	*F*	*Significance F*
Regression	1	23507712	23507712	116.505	5E-10
Residual	21	4237251	201773.9		
Total	22	27744963			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	58.8737	175.5543	0.335359	0.74068	-306.21	423.959
CO_2 Seq.	0.00458	0.000424	10.79376	5E-10	0.0037	0.00546

Table 6: Correlation coefficient between CO_2 sequestered and emitted in Omo Biosphere Reserve, Nigeria

	CO_2 Seq.	**CO_2 emitted**
CO_2 Seq.	1	
CO_2 emitted	0.920477	1

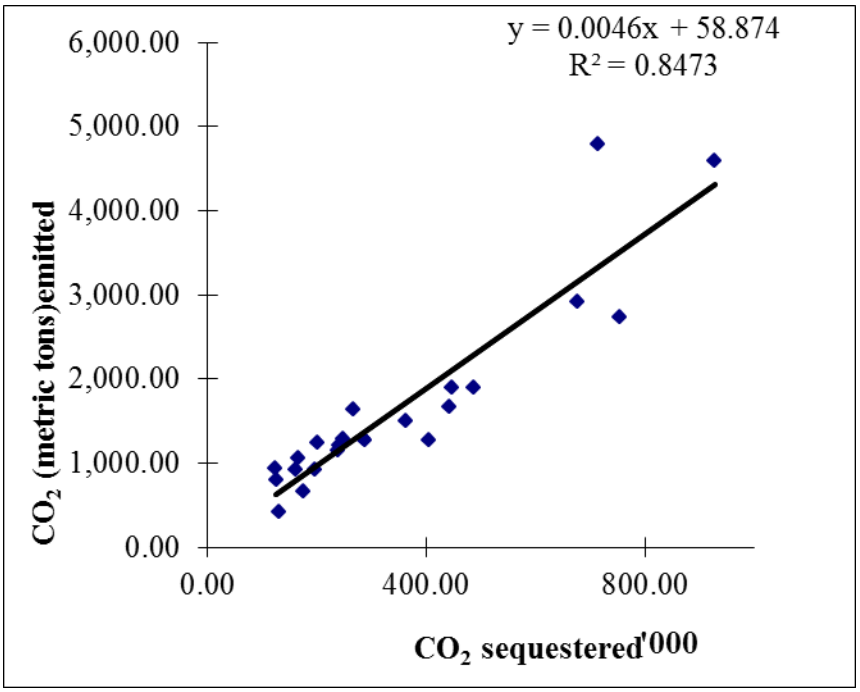


Figure 3: Carbon-dioxide sequestered and emitted in metric tons per hectare in Omo Biosphere Reserve, Nigeria

DISCUSSION

Land use land cover classification

Percent area of classification of land cover in Omo Biosphere Reserve as shown in table 1 indicated that there is reduction in water body from 2.2 percent to 1.6 percent in 2002 and 2015 respectively. This could be as a result of canopy closing of some water tributaries. There is increase in light forest from 37.4 percent to 41.8 percent in 2002 and 2015 respectively, while there was decrease in thick forest from 60.4 percent to 56.6 percent in 2002 and 2015 respectively. These results indicated that thick forest is decreased and light forest increased.

The output of regression analysis between carbon dioxide sequestered and emitted is showed as $R^2 = 0.8473$.

Carbon-dioxide emitted if forest is burnt or deforested

The prediction that carbon-dioxide would be emitted if forest is burnt or deforested depend on the growth characteristics of the tree species, the conditions for growth, and the density of the tree's wood. The more sequestered carbon, the more carbon-dioxide would be emitted. Forest would emit 2134.59 metric tons per hectare (62%), while savanna/rock_outcrop would emit 45.7152 metric tons per hectare (1%). It is therefore concluded that the rate of carbon stock commensurate to carbon loss.

The regression analysis between CO_2 sequestered and emitted in Omo Biosphere Reserve, Nigeria

The CO_2 sequestered and emitted per plot is indicated in table 1. The output regression analysis between the two estimates showed a high regression R^2 0.8743 (87.43%). There is also high percentage of correlation of 92 percent. Evidence shown in this result indicated that there is high confidence that CO_2 sequestered has correlation with CO_2 emitted. While correlation coefficient of 92 percent equally suggested high correlation between the two variables. This is a good relationship.

REFERENCES

Lu, D. (2005). Above ground biomass estimation using Landsat TM data in the Brazilian Amazon .*International Journal of Remote Sensing*, 26(12), pp 2509-2525.

IPCC 2006 IPCC Guidelines for national greenhouse gas inventories, prepared by the National Greenhouse Gas Inventories Programme. Eggleston, H.S., Buendia, L., Miwa, K., Ngara, T. and Tanabe, K. (eds.). Institute for Global Environmental Strategies (IGES), Japan. http://www.ipccnggip.iges.or.jp/public/2006gl/index.html (25 Nov. 2008).

Sierra, C. A., del Valle, J. L., Orrego, S. A., Moreno, F.H., Harmon, M. E., Zapata, M., 2007). Total carbon stocks in a tropical forest landscape of the Porce region, Colombia. (Article).*Forest Ecology and Management*, 243(2-3), pp 299-309.

Development of Digital Elevation Models for Omo Forest Reserve Nigeria

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ABSTRACT

Digital Elevation Model (DEM) is a very important geospatial data used in modeling different hydrological and ecological phenomenon which are required in preserving our micro environment. DEMs are typically used to represent terrain relief. DEMs are particularly relevant for many applications such as lake and water volumes estimation, soil erosion volumes calculations, flood estimate, quantification of earth materials to be moved for channels, roads, dams, embankment etc. In this study, a total of 1,849 points coordinates with their respective elevations were obtained covering the entire study area. The algorithm used includes interpolated natural neighbour of Quantum Geographic Information System (QGIS) to generate Digital Elevation Model (DEMs) for the forest reserve. The contour lines were extracted from DEM at interval of 20 m from one another. It was observed that the presence of Omo river at the southern part of the reserve is responsible for the very low altitude obtained. On the other hand, the altitude at the northern part of the reserve is relatively high because of the presence of rock outcrop, which also makes the vegetation to be scanty. Therefore, Geographic Information System was used to develop Digital Elevation Model for Omo forest reserve to serve as baseline information for the study area.

Keywords*:* Digital elevation model, development, geographic information system, omo forest reserve.

INTRODUCTION

Digital elevation models (DEMs) are digital representations of ground surface topography or terrain that provides quantitative elevation data for many applications in topographic and land cover studies, geomorphology, etc. (Miliaresis and Kokkas, 2007; Miliaresis, 2008; Miliaresis and Delikaraoglou, 2009; Isioye and Jobi, 2011). Digital Elevation Models (DEMs) are useful in many applications, such as topographic mapping, earth's deformation, hydrological and biological studies (Isioye and Jobi, 2011). It provides either bare earth (ground) – termed as digital terrain models (DTMs) – or elevations with respect to the reflective surface (which may be vegetation, human-made features, etc.) – termed as digital surface models (DSMs). The U.S National Elevation Dataset (NED) gives bare earth elevations (DTM) for the conterminous U.S.A (Osborn *et al.,* 2001). The Shuttle Radar Topography Mission (SRTM) provides DSM elevation data for the majority of Earth's land surface (Rodriguez, *et al.,* 2006

It is of immense significance to distinguish between DEMs and other form of terrain representation; the two most closely used and confused with DEMs are Digital Terrain Model (DTM) and Digital Surface Model (DSM). DTM is considered as a continuous usually smooth surface which, in addition to height values (as DEMs) also contains other element that describes a topographic surface; slope, aspect, curvature, gradient, and others (Isioye and Jobi, 2011). Like Digital Terrain Models, Digital Surface Models contain the spatial elevation data of the terrain in digital format which is usually presented as a grid with natural and artificial features such as vegetation, buildings etc. A filtered DSM result to DTM and a DEM is considered the most important component of DTM (Maume *et al.,* 2001; Li *et al.,* 2005; Jobin, 2010). A wide range of application is now drilling the requirement for increased details in Digital Elevation Models (DEMs). Details in this instance are defined by the horizontal sample spacing and vertical accuracy of the measurement. DEM is also an important utility of Geographic Information System (GIS). Using DEM/3D modelling, landscape can be better visualized leading to a better understanding of certain relation in the landscape. Many relevant calculations, such as lakes and water volumes, Soil Erosion Volumes, quantities of earth to be moved for channels, dams, roads, embankments, etc. (ESRI, 2009). The derivation of topographic attributes relies on digital elevation data sets that may be acquired from satellite imagery, digitizing the contour lines on topographic maps, or conducting ground surveys (Wilson and Gallant, 2000). Digital elevation data are typically compiled and stored in one of three data structures; point elevation data on a regular grid, point elevation data in triangulated irregular networks, and

digitized contour line data. The popularity of square grid DEMs is owed to their visual simplicity and ease of computer implementation (Moore *et al*., 1991; Wilson and Gallant, 2000).

However, in forestry, we are concern with aspect of DEM that have to do with micro climate. For instance, decreasing air temperature usually coincides with increasing elevation, which directly influences the length the growing season at different altitudes (*Daubenmire, 1943; Clarke, 1997; Blasco, et al., 2000).* In addition, plants can be especially sensitive to soil temperatures and can have specific elevation ranges that support healthy growth (*Blasco, et al., 2000; Miliaresis and Delikaraoglou, 2009).*

Another climatic element that DEM can help us determine is humidity. Precipitation levels, atmospheric humidity, and potential for evapotranspiration, varies with altitude and is a significant factor in determining altitudinal zonation (*Miliaresis and Delikaraoglou, 2009).* The most important variable is precipitation at various altitudes (*Mulligan, 2011).* The greatest amount of rainfall is expected at mid-altitudes and can support deciduous forest development. Above a certain elevation the rising air becomes too dry and cold, and thus discourages tree growth. One of the most important factors that control the lower boundary of the encinal or forest level is the ratio of evaporation to soil moisture *(Mulligan, 2011).*

The nutrient content of soils at different altitudes further complicates the demarcation of altitudinal zones. Soils with higher nutrient content, due to higher decomposition rates or greater weathering of rocks better support larger trees and vegetation. In the tropical rain forest regions, lower elevations exhibit fewer terrestrial species because of the thick layer of dead fallen leaves covering the forest floor (*Clarke, 1997; Blasco, et al., 2000).* At this latitude more acidic, humus soils exist at higher elevations in the montane or subapline levels (*Miliaresis and Delikaraoglou, 2009)*. In a different example, weathering is hampered by low temperatures at higher elevations in the Rocky Mountain of the western United States, resulting in thin coarse soils (*Miliaresis and Delikaraoglou, 2009; Mulligan, 2011).* This study is aimed at providing basedline information on Omo forest reserve with a view to determining the implication on the forest ecosystem.

METHODOLOGY

Study Area

The study was carried out in Omo forest reserve in Ijebu-Ode East local government area of Ogun State, Nigeria. The reserve is bounded by Benin-Shagamu expressway to the south and Omo River and Oni River to the east. It is situated between latitude 6^0 35' and 7^0 05'N and longitude 4^0 40'E. (Akindele, 1991; Onyekwelu, 2001; Alo *et al*., 2011). The reserve is divided into four sections, which are Area J1, J3, J4 and J6 (Onyekwelu, 2001). Omo Forest Reserve has bear rocky out crops occurring occasionally along its northern boundary. A total of 1,849 points coordinates with respective elevation were obtained at various locations across the study area. The coordinates and elevation was saved in text (tab delimited) file format in Microsoft Excel. This was loaded into QGIS for further analysis. The algorithm used includes interpolated natural neighbour of SAGA 2.1.2 geoalgorithm in Quantum Geographic Information System (QGIS) to generate Digital Elevation Model for the forest reserve. The Coordinate Reference System (CRS) was WGS84. The contour lines were extracted from DEM at interval of 20 m from one another. Satellite images were used to compare the forest stands at the south and the north of the forest reserve were obtained from the google earth.

RESULTS AND DISCUSSION

The summary of the data collected in Omo forest reserve is presented in Table 1 while the distribution of elevation across the forest reserve is shown in Figure 1. It appears the frequency distribution of the elevation is slightly positively skewed or asymmetrically to the right. This implies most of the areas covered are concentrated in low altitudes. This is seen in the DEM developed in this study for Omo forest reserve. A total of 1849 points coordinates with elevation were obtained across various locations within the forest reserve (Table 1 and Figure 2). The coordinates ranged between latitude 7.105646˚ N and 6.632964˚ N and longitude 4.213955˚ E and 4.558935˚ E. The data summary revealed that the mean altitude in Omo forest reserve is 91.47 m asl and it ranged from 6 m asl to 249 m asl. This result is not the same with the one obtained by Onyekwelu, (2001) when he reported that the average elevation at Omo forest reserve was about 123 m above sea level, elevation may reach 154 m above sea level in the northern part due mainly to occasional hills and rocky outcrops) and could be as low as about 30 m along the valley of the main river. No research has been reported to obtain up to 1849 points coordinates and elevation in the study area. This study presents more reliable base line information than earlier presented by Onyekwelu, (2001) because of the spread of the data collected (Figure 2).

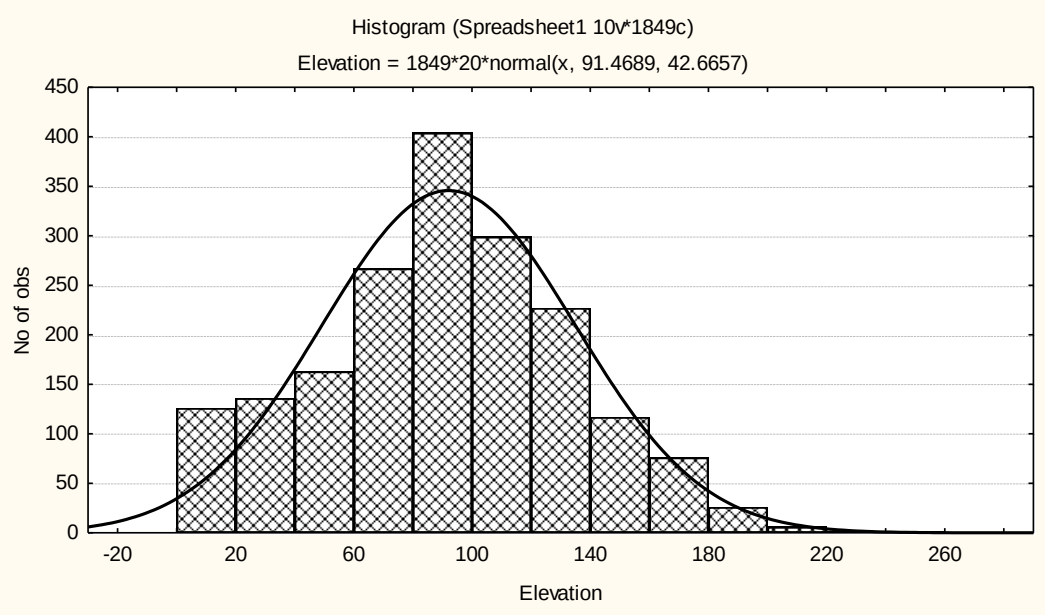


Figure 1: Distribution of elevation in Omo forest reserve

Table 1: Summary of data collected for DEM in Omo forest

	No. of Observation	Mean	Minimum	Maximum
Elevation (m)	1849	91.47	6.00	249.00
Longitude (˚ E)	1849		4.21396	4.55894
Latitude (˚ N)	1849		6.63296	7.10765

From the point coordinates, DEM was developed as shown in Figure 3. The DEM colour ranged from blue at the southern part of the reserve to red at the northern part especially towards the Northeast and Northwest. At the center of the reserve, the blues colour faints gradually until its takes up red colour. Figure 4 shows the contour lines extracted from DEM. From the figure, elevation is as low as 6 m asl at the southern part of the reserve. This was increased to about 250 m asl at the northern part of the reserve. The central part of the reserve has elevation range of 60 m and 120 m asl.

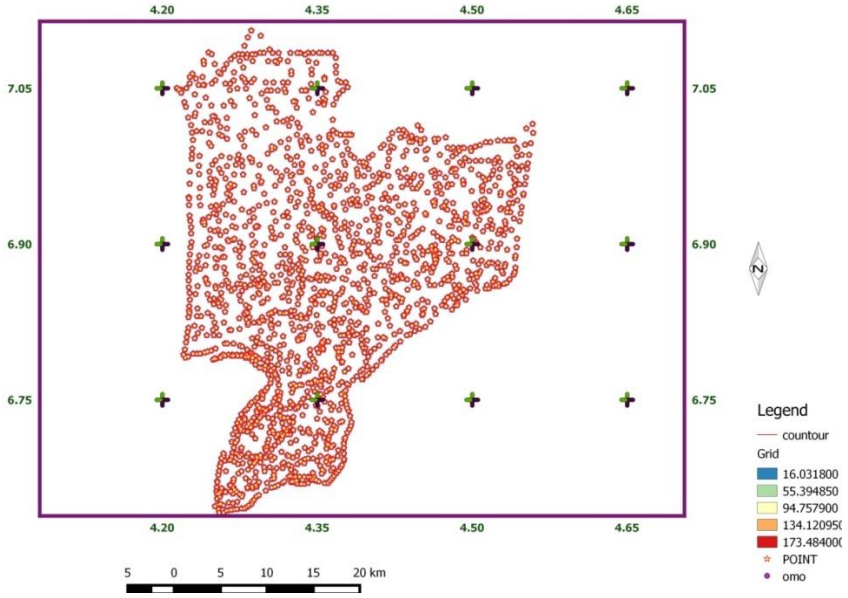


Figure 2: Data point obtained from Omo Forest Reserve

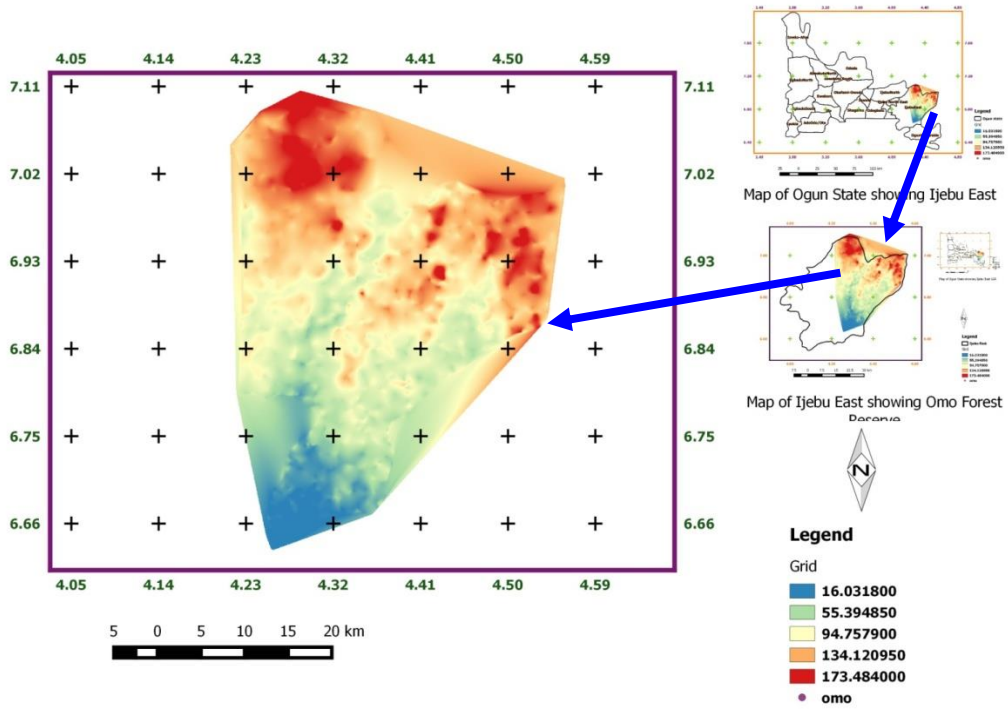


Figure 3: Digital Elevation Model of Omo Forest Reserve

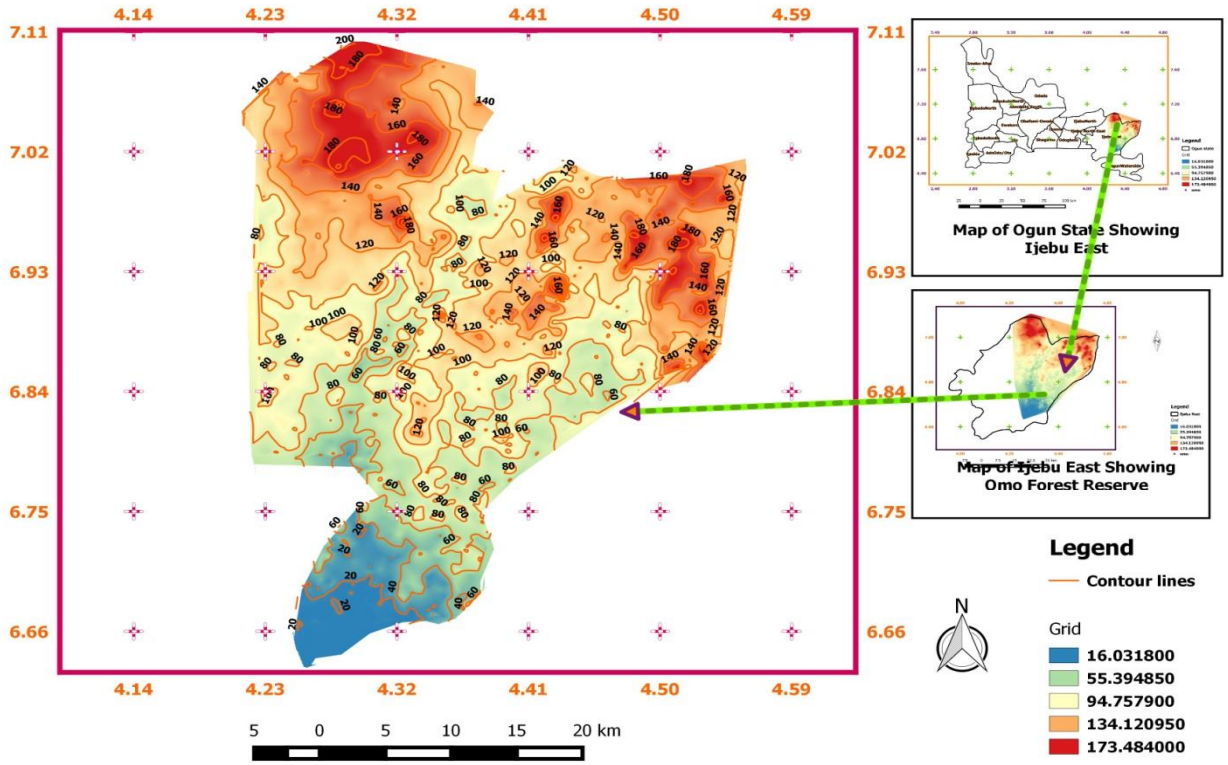


Figure 4: Contour lines of Omo Forest Reserve on Digital Elevation model.



Figure 5: Satellite imagery of the Southern part of Omo Forest Reserve

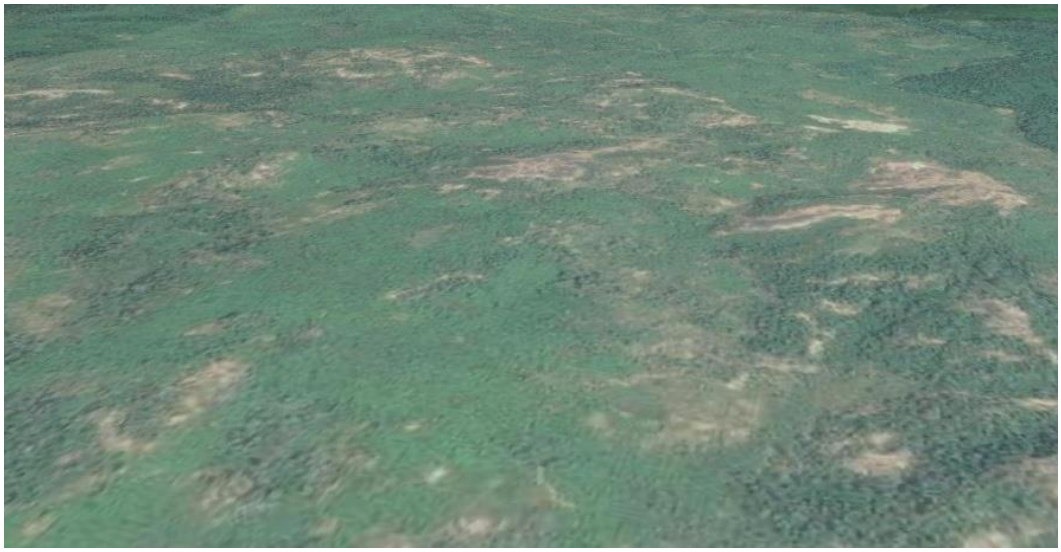


Figure 6: Satellite imagery of the Northern part of Omo Forest Reserve

The southern part of Omo forest Reserve is characterized with blue colour DEM (Figure 4) and low elevation contour (6 m asl) in Figure 5 due to the presence of Omo river, which flows down from the western part of the reserve as observed from the satellite imagery of the southern part of the reserve. This also explains the reason why at the center of the reserve, DEM have pale blue colour while the contour is ranged between 60 m asl and 120 m asl. Of course, the largest land areas in the reserve fall within this altitude. The vegetation in this area is dense deciduous forest. Due to the dense deciduous forest as revealed by the satellite imagery in Figure 5, the forest cover would have over the years, ameliorate the micro climate such that the temperature would have been relatively be reduced compare to what is obtained at the northern part of the reserve. This is because air temperature correlate with elevation, which directly influences the length of growing season at different altitudes (*Daubenmire, 1943; Clarke, 1997; Blasco et al., 2000).* The northern part of the reserve is characterized with high elevation and DEM also revealed high altitude. The satellite imagery of the northern part of Omo forest reserve (Figure 6) showed that there are rock outcrops at the entire northern fringe especially at the northeast and northwest. This rock outcrop is responsible for the high values of elevation (249 m asl). At the altitude more than this, the soil may be more acidic, humus soils exist at higher elevations in the montane or subapline levels *(Miliaresis and Delikaraoglou, 2009).* Weathering is hampered by low temperatures at higher elevations resulting in thin coarse soils (*Miliaresis and Delikaraoglou, 2009; Mulligan, 2011; Coit and Mack, 2014; Isioye and Jobin, 2012; Leon, 2011; Paudel, Oguchi, and Hayakawa, 2016). The highest altitude in the study area is not regarded as threshold for acidic soil. However, the forest in this zone is scanty as a result of patches of rock outcrops and probably only those trees that can thrive in rocky soil will be able to survive.*

CONCLUSION AND RECOMMENDATION

Geographic information system has been used in this study to develop Digital Elevation Model for Omo Forest Reserve and contour line has been extracted from same. The average elevation is 91.47 m asl. The coastal areas as a result of Omo river have low altitude of 6 m asl at the southern part while the rock outcrops are responsible for the high elevation of 249 m asl at the northern fringe of the reserve. The various altitudes also affect the distribution of vegetation in various locations as revealed by the satellite imageries.

This study has provided base line information on the relief of Omo Forest Reserve. Therefore, the information should form a basis for further research.

REFERENCES

Akindele S.O. (1991): Development of a site index equation for teak plantation in South Western Nigeria. *Journal of tropical forestry science Vol. 4: Pp162-167.*

A. A., Alo, J. C. Onyekwelu and S. O. Akindele, (2011): Taper equations for *Gmelina arborea* in Omo forest reserve, southwestern Nigeria. *Journal of Applied Tropical Agriculture*, , Vol. 16. No (1&2). Pp120-127.

Blasco, F.; Whitmore, T.C.; Gers, C. (2000). "A framework for the worldwide comparison of tropical woody vegetation types". Biological Conservation. 95 (2): 175–189. doi:10.1016/S0006-3207(00)00032-X. Archived from the original (PDF) on 2012-09-04. Retrieved 2012-03-11. p. 178.

Clarke, C.M. (1997). Nepenthes of Borneo. Kota Kinabalu: Natural History Publications (Borneo). p. 29.

Coit, J., and Mack, M. (2014): Rhode Island Soil Erosion and Sediment Control Handbook Rhode Island State Conservation Committee Rhode Island Department of Environmental Management Rhode Island Coastal Resources Management Council Rhode Island pp, 422.

Daubenmire, R.F. (1943). "Vegetational Zonation in the Rocky Mountains". Botanical Review. 9 (6): 325–393.

ESRI, (2009). *Overview of Geographic information system (GIS)*. Available at www.gisdevelopment.net/turtorials/tuman006.html.*Grace, John; Berninger, Frank; Nagy, Laszlo (2002). "Impacts of Climate Change on the Tree Line". Annals of Botany. 90 (4): 537–544. doi:10.1093/aob/mcf222. PMID 12324278. .*

George Miliaresis and Demitris Delikaraoglou, (2009): Effects of Percent Tree Canopy Density and DEM Misregistration on SRTM/NED Vegetation Height Estimates. *Remote Sensing.* Vol. *1*, 36-49;

Isioye, O. A., and Jobin, P. (2012): An assessment of digital elevation models (DEMs) from different spatial data sources. *Asian Journal of Engineering, Sciences & Technology*, *2*(1), pp1–17.

Jobin, P.D. (2010). *An Assessment of Digital Elevation Models (DEMs) From Different Spatial Data Sources*. BSc Project, Department of Geomatics Engineering, Ahmadu Bello University, Zaria-Nigeria.

Leon, B. L. F. (2011): *Step by Step Geo-Processing and Set-up of the Required Watershed Data for MWSWAT (MapWindow SWAT)pp23*.

Li, Z., Zhu, Q., and Gold, C. (2005). *Digital Terrain Modeling: Principles and Methodology*. CRC Press: Boca Raton, FL, 323 pp.

Maune, D.F., Kopp, S.M., CA Crawford, C. A., and CE Zervas, C.E. (2001). Introduction. In Maune DF (ed). Digital Elevation Model Technologies and Applications: The DEM Users Manual (American Society for Photogrammetry and Remote Sensing: Bethesda, MD), 1–34.

Miliaresis, G., and Delikaraoglou, D. (2009): Effects of percent tree canopy density and DEM misregistration on SRTM/NED vegetation height estimates. *Remote Sensing*, *1*(2), 36–49.

Miliaresis, G and Kokkas, N. (2007): Segmentation & Object Based Classification for the Extraction of Building Class from LIDAR DEMs. *Comput. Geosci.* 2007, *33*, 1067-1087. *Remote Sens.* 2009, *1* 48

Miliaresis, G. (**2008):** Quantification of Terrain Processes. *Lecture Notes in Geoinformation & Chartography, 14*, 13-28.

Moore, I. D., Grayson, R. B., and Ladson, A. R. (1991). Digital Terrain Modeling: A review of hydrological, geomorphological, and biological applications. *Hydrological Processes* 5: 3-30.

Mulligan, M. (2011). "Modeling the Tropics-Wide Extent and Distribution of Cloud Forest and Cloud Forest Loss, with Implications for Conservation Priority". In Bruijnzeel, L. A.; Scatena, F. N.; Hamilton, L. S. Tropical Montane Cloud Forests: Science for Conservation and Management. Cambridge University Press. pp. 15–38.. Retrieved 2012-03-09.

Olalekan A. Isioye, and Jobi N Paul, (2011): An Assessment of Digital Elevation Models (DEMs) From Different Spatial Data Sources. Spatial Information Processing I . Pp17Onyekwelu, J. C. (2001): Growth characteristics and management scenarios for plantation-grown *Gmelina arborea* and *Nauclea diderrichii* in south-western Nigeria. Hieronymus Verlag, Munich, 196 Pp

Osborn, K.; List, J.; Gesch, D.; Crowe, J.; Merril, G.; Constance, E.; Mauck, J.; Lund, C.; Caruso, V.; Kosovich, J. (2001): In: *Digital Elevation Model Technologies and Applications, the DEM Users Manual*; Maune, D., Ed.; American Society for Photogrammetry and Remote Sensing: Bethesda, MD, USA, 2001; Chapter 4, pp. 83-120.

Paudel, U., Oguchi, T., and Hayakawa, Y. (2016): Multi-Resolution Landslide Susceptibility Analysis Using a DEM and Random Forest, 726–743.

Rodriguez, E.; Morris, C.S.; Belz, J.E. (2006): A Global Assessment of the SRTM Performance. *Photogramm. Eng. Remote Sens.* 2006, *72*, 249–261

Wilson, J.P., and Gallant, J. C. (2000). *Digital terrain analysis*. In Wilson, J.P., and Gallant, J. D. (eds). Terrain Analysis; Principles and Applications. John Wiley and Sons: New York, NY, 1–27.

SUB-THEME 6



Sustainable Utilization of Forest Products and Herbal Medicine

Survey of Preference to Quality Wood in Selected Plank Markets in Ibadan Metropolis

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ABSTRACT

Consumer is an individual that has choices, makes decision and plans based on his or her preferences. This study is aimed at examining consumer's response to quality wood in the selected plank markets. Questionnaires was administered was administered to obtained information on status of consumers, acceptability of wood, rate of demand, availability of the wood, income, market forces and other relevant vital information. A total of 90 questionnaires were administered among the three markets according to their sizes. Thirty-five, 30 and 25 questionnaires were administered at Bodija plank market, Sango plank market and Oke-Ado plank market, respectively. Results showed that quality wood was on high demand despite the high and fluctuating prices on planks. Bodija market had the highest demand of planks with 91.4 percent. Sango and Oke-Ado plank markets had 63.3 percent and 44 percent, respectively. The response of consumers to quality wood was based on personal satisfaction and profit generated from it. Quality wood was much more durable and the study confirmed the increase response of consumers to its demand.

Keywords: Consumer preference, quality plank, plank market,

INTRODUCTION

Wood is hard, fibrous and cellulosic material as trees and shrubs or versatile cellulosic materials of trees which have multipurpose use (Webster, 1990). It is stated that wood has been in existence before man appear on earth and has contributed to the survival of man civilization. Nowadays, wood has great impact on the economy due to its utilization. Wood is renewable, reusable and recycleable material. In tree, structurally, wood is the only construction material, which is a net consumer and store of carbon dioxide (CO_2) thus, giving a beneficial effect in reducing global warming (Morris, 1998). Due to this diversity in natural and character of wood, exploitation of trees for structural and construction purposes was selective and limited to the very strong and durable species such as *Milicia excels, khaya sp., Afzilia Africana, Nauclea diderrichii, Triplochiton scleroxylon, Terminalia sp,* and *Cordia millenii* (Ifebueme. 1997); Onilude and Ogunsanwo, 2002). The overall exploitation of these species had led to their scarcity in the timber market and their high cost (Aguda, 2012).

Since most defects occur before the consumer comes into possession of the wood, there is little he can do to prevent them, but he can least-recognise them for what they are decide on their seriousness or otherwise as regards the job in hand, and possibly even reject the wood as unsuitable for its purpose because of the defect. Due to defect the quality of wood is greatly hampered hence the choice of the consumer is greatly limited, this study tends to examine the consumers response to quality wood despite its limited supply.

MATERIALS AND METHODS

Study Area

The study was carried out in Ibadan city which is situated in 7^0 North of the equator at height of 784 feet above sea level. The city itself covers a geographical area of well over 100 square kilometers. Ibadan city is administered by five local governments comprising Ibadan North with its head office in Agodi; Ibadan North East-Iwo road; Ibadan North West-Onireke; Ibadan South West-Oluyole estate; and Ibadan South East-Mapo. Three major plank markets namely; Bodija plank market, Oke-Ado plank market and Sango plank market were sampled for the study. A total of 90 questionnaires were administered and divided among the three markets according to their sizes. Thirty-five questionnaires were administered at

Bodija market, thirty at Sango market and twenty five at Oke-Ado plank market. The data were collected on the status of the consumer, the rate of demand, acceptability of wood, availability of wood, market forces for wood, income pattern and other relevant information. The data collected were analyzed using descriptive statistics.

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RESULTS AND DISCUSSION

Demographic characteristics

Table 1 showed that 57 respondents (80.3%) of the total respondents were males while 14 of the respondents (19.7%) were females. Twenty three respondents (32.4%) were single while 48 (67.6%) were married. This signified that majority of the consumers of wood were married. The prominence of male is in support of the long held notion that men generally take the lead on issues of wood products' matters (Fabeku and Akinsulire, 2008; Jegede, 2010). Table 1also indicated that 16.9 %t were between 15 and 30 years of age, 52.1% were between 46 and 61 years of age. Only 9.9 % were over 61 years old. The ultimate consumers of wood were in the middle age class of people who can easily recognize and differentiate quality wood from defective wood.

Table 1

Variables	Frequency	Percentage
Sex		
Male	57	80.3
Female	14	19.7
Total	71	100
Marital status		
Single	23	32.4
Married	48	67.6
Divorced	-	-
Total	71	100
Age (Years)		
15-30	12	16.5
31-45	37	52.1
46-61	15	21.1
Above 61	7	9.9
Total	71	100

Source: Field survey, 2000

Non-demographic characteristics

Table 2 showed that consumers demand for quality wood for their satisfaction. The result showd that demand for quality wood in Bodija, Sango and Oke-bola were 91.4 %, 63.3 4 %,, 44 4 %, respectively. Many preferred quality wood thus enhancing its demand in the various markets. Table 2 also showed that the supplies of quality wood in the market were enough for the consumers to buy. At bodija market 91% percent answered Yes to adequate supply, 8.6 % answered No. At Bodija, sango and Oke-Ado plank markets, 91.4%, 63.3% and 44%, respectively were satisfied with the supply of wood while only 24 % were not satisfied. This indicated that there was good supply of quality wood in the three markets. Table 2 showed that despite the fluctuating and expensive price on good quality wood large numbers of the respondents still prefer to buy the same quality. The result showed that at Bodija plank market, 30 respondents reacted favorably to the price which did not affect their buying rate, even when the price was increased. At Sango plank market 16 respondents confirmed that pricing did not affect them while 17 respondents at Oke-Bola market. The result made it clear that increase in price of quality wood had no impact on the quality the consumers are purchasing. Table 2 showed that majority of the respondents reacted to pricing system in the market as the major problem facing them. Twenty respondents confirmed that uncontrolled pricing system in the market was the problem encountered. This showed pricing system had effect on the consumers' quality wood.

Table 2: Non- demographic characteristics

Markets	Number of Respondents		Percentage	
Quality	Yes	No	Yes %	No %
Bodija	32	3	91.4	8.6
Sango	19	0	63.3	0
Oke-Bola	11	6	44	24.0
Total	62	9		
Income				
Bodija	35	-	100	-
Sango	19	-	63.3	-
Oke-Bola	17	-	68	-
Price				
Bodija	30	5	85.7	14.3
Sango	16	3	53.3	10.0
Oke-Bola	17	0	68.0	0
Total	63	8		

Problems	Number of Respondents	Percentage
Transportation	17	23.9
Lack of fund	15	21.1
Power failure	19	26.8
Pricing system	20	28.2
Total	71	100

Source: Field Survey, 2000

Frequency of Visit of the Consumers to the Plank Markets

Table 3 showed the response of the consumers at all markets on their degree of visitation. Daily respondents were 8.5% in the three markets; these consumers were found to be small scale carpenters.. Respondents (71.8 %) purchased wood weekly and found to comprise big furniture companies, builders and carpenters while 19.7% respondents purchased quality wood monthly. Frequency of visit by the consumers depended on the purpose of which the wood was to be subjected and the rate of consumption of the wood by the ultimate consumers. Table 3 also showed that no single buyer or sellers would ever be in position to influence the conditions of the market by increasing or reducing price. The frequency of visit determined the rate of supply of quality wood into the market. From the study, there was great demand for quality wood by the consumers in which increase in the price had no effect on the quantity purchased. The consumption of wood was a generalized issue among individuals either directly or indirectly, they need wood for one thing or the other. It was observed that the supply of quality wood was always in excess in the markets sampled. This was possible because of the continuous demand and price differences. It was observed that consumer purpose of preferring quality wood was to satisfy their wants on the wood not minding the high price of the wood. What the consumer sees is not the commodities themselves, but their attributes; the quantities with reference to which he exercised his taste in accordance to Oluyode and Nurudeen (1987).

Table 3: Frequency of visit of the consumers

Frequency of Visit	No of Respondent	Percentage
Daily	6	8.5
Weekly	51	71.8
Monthly	14	19.7
Total	71	100

Source: Field Survey, 2000

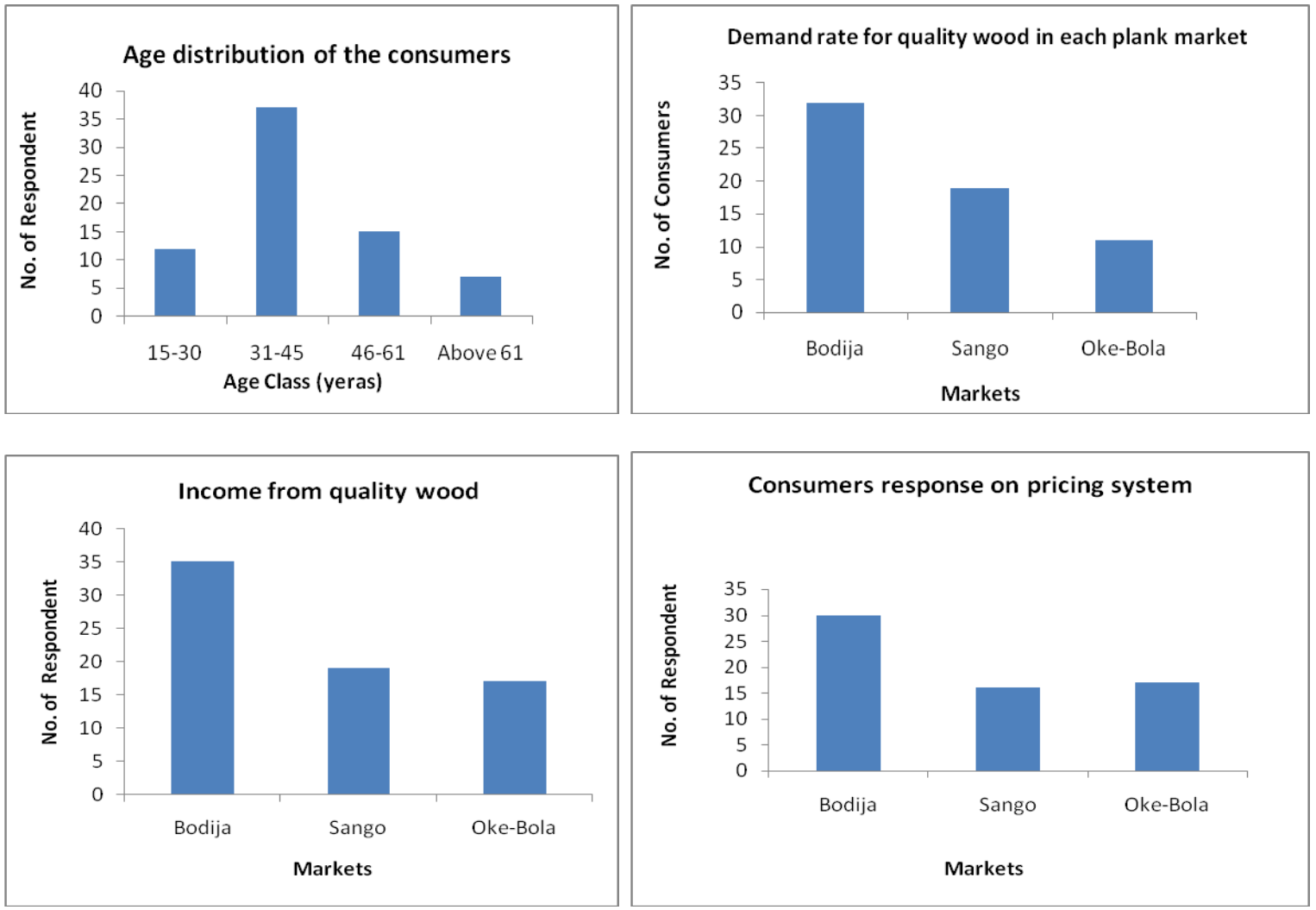


Fig 1: Showing the age distribution, demand rate, income and consumers response on pricing system of wood quality.

CONCLUSION AND RECOMMENDATIONS

From the results of this study it was concluded that the consumers preferred quality wood to defective wood without considering the high price of the wood. This was just to satisfy their need because of its durability. The frequency of visit of the consumers to the market weekly confirmed how individual were consuming wood. The major problem encountered by the consumers in quality wood consumption was pricing system of the market which fluctuates occasionally. The consumers of quality wood were mainly the working class who were at their late youth age. Consumers' demand rate for quality wood would continue because of the properties wood possesses. Wood should be defect free and it is very durable. It is therefore, recommended that for continuity in demand and supply of quality wood in the market, price control board should be set up by the government like other sectors to supervise the marketing (demand and supply) of sawn timber at the local, state and federal levels. This will enhance smooth and amiable distribution of wood among sellers for the consumers to satisfy their needs. This in turn would minimize problems encountered in pricing and grading rules.

REFERENCES

Aguda L.O., Adejoba O.R., Ajayi B., and Adegoke A.L. (2012): Evaluation of selected physical properties of *Chrysophyllum albidum*: a lesser used species. Proceeding of the Division 5 International Union of Forestry Organization (IUFRO) Lisbon, Portugal, 8th-13th July, 2012.pp.240

Fabeku, P.O. and Akinsulire, O. (2008). The role of traditional medicine among the Yoruba of South-west, Nigeria. In: Odugbemi, T. (ED.) A text Book of Medicinal Plant from Nigeria. University of Lagos Press. Pp 43-54.

Odugbemi, T. (2008). (Ed.) A text Book of Medicinal Plant from Nigeria. University of Lagos Press.

Oluyode and Nurudeen. Fundamental of wood work practice and Thanni, Y.A(1987). Evans Brothers Limited, Jericho road, Ibadan.

Ogunsanwo, O.Y. (2000). Characterization of wood properties of plantation grown Obeche (*Triplochiton scleroxylon* K.Schum) in Omo Forest Reserve, Ogun State, Nigeria. PhD. Thesis. Dept. of Forest Resources Management University of Ibadan. 227pp

Webster (1990). New Encyclopedia Dictionary. Balack Doand Leventhal Publishers In. New York.

Evaluation of Fibre Characteristics of Kenaf (*Hibiscus cannabinus* and *Hibiscus sabdarrifa*) and Yellow Bush (*Duranta repens*)

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ABSTRACT

This study evaluated the fibre characteristics of selected non wood species: Hibiscus saabdarriffa, Hibiscus cannabinus and Duranta repens. Experimental samples were obtained from the root, stem, leaves and flower of these species at Federal College of Forestry, Ibadan. Acetic acid (CH_3COOH) and Hydrogen Peroxide (H_2O_2) at ratio 1:1 in test tubes were placed in oven at a temperature of 101 ± 2^oC for 72hours to macerate the samples. Ten samples each were then viewed under electronic microscope and the following parameters: Fibre length, fibre diameter, fibre lumen width and fibre cell wall thickness were measured. Result showed that the fibre length of Duranta repens ranged from 0.59 to 0.83mm, runkel ratio ranges from 0.82 to 0.85mm while fibre length of Hibiscus sabdariffa ranged from 0.53 to 0.96mm and runkel ratio ranges between 0.95 to 0.58mm and Hibiscus canabinus fibre length ranged from 0.71 to 1.02mm with runkel ratio ranged from 0.67 to 0.83mm. It was observed that the stem of Hibiscus canabinus have the longest fibre length of 1.02mm followed by Hibiscus sabdarriffa 0.96mm and the least from Duranta repens (0.83mm). Analysis of variance showed significant difference only in fibre length of the root 5% probability while the fibre diameter, lumen and cell wall thickness were not significant. All the species were considered suitable for papermaking since runkel ratio values is less than 1. These species would therefore be a good raw material for papermaking.

Keywords: Evaluation, maceration, fibre length, runkel ratio.

INTRODUCTION

Fibres are generally classified into major groups known as natural fibres, which include vegetable fibres, animal fibres, mineral fibres and man-made fibres examples of which are generated fibres, non- cellulosic polymer (synthetic fibre) and metallic fibre, yarns, staple and thermoplastic and non-thermoplastic. This classification is on the basis of their origin, length and heat conductivity (Slideshare, 2010). Preliminary research works by Ogunsile, *et al*., (2008), Akpabio and Akpankpan, (2012) have proved that banana and plantain fibres can be used for various domestic, commercial, and industrial purposes such as papermaking rope, carpet backing and other similar cordage uses. Relating to this are sisal and abaca which are grown as ornamental in Nigeria but are of commercial importance in Philippines and East Africa (McLaughlin and Schuck, 1991, Ates, *et al;* 2008). Apart from these, other leaf fibres such as Kenaf (Udohitinah and Oluwadare, 2011), hesperaloe, giant reed, nal grass and yucca (Ravetta and Mclaughlin, 1996) have been found to be useful industrial materials.

Kenaf fibre is getting attention of industries and researchers to utilize it in different polymer composites due to environmental awareness of consumers, industries and government regulations in various countries (Raman Bharath *et al*., 2015). They are light in weight and nontoxic. They possess low tool wearing rates, good thermal insulation properties and acoustic properties. They are relatively stronger and being considered for making various products which can be used in construction industry, automotive industry and for furniture production. Paukszta and Borysiak (2013), Davoodi *et al.*, 2010, Zhu *et al.*, 2013. Anuar and Zuraida (2011) found that use of kenaf fibres are increasing as significant natural material sources contributing towards the development of eco-friendly assets for the automotive, sports industries, food packaging and furniture industries.

Kenaf is in an advanced position when compared with other lignocelluloses fibre crops since it has a short plantation cycle, flexibility to environmental conditions and requires relatively lowered quantity of pesticides and herbicides Wang and Ramaswamy (2003). Nishino *et al.*, 2003 claimed that mechanical strength and thermal properties of kenaf composite are superior to other natural fiber composites, thus suitable for high performance applications. Even though the natural fibres have several advantages, they carry some

restrictions such as pitiable resistance to moisture especially absorption and low strength compared to synthetic fibre such as glass [Hazizan *et al.*, 2009].

This study was conducted to evaluate the fibre characteristics of Kenaf and *Duranta repens* with a view to recommending its fibre for papermaking

METHODOLOGY

The sample of yellow bush was collected around the school premises of Federal College of Forestry Ibadan while Kenaf was collected at Forestry Research Institute Arboretum. Samples were taken from the leaves, stem, flower and root of the plant. The samples of various plants were collected and cut into match stick size (chip) about 2mm long and 1.5mm wide, the chips were placed inside the test tubes containing a mixture of acetic and Hydrogen peroxide in ratio 1:1 and properly labelled. The same procedure was done for all the samples. Samples of the plant were soaked in chemicals and placed in test tube rack and later in the oven at temperature of 100^{o}C for 3 days to macerate i.e. for lignin and hemicelluloses to dissolve, leaving cellulosic fibre only.
After 3 days, the test tube containing the chips and chemical were checked which would have turned whitish before its removal from oven. The left over chemical in the test tube was then decanted while the fibres were washed twice in distilled water. Samples were taken with spatula into the open slide and were viewed under a powerful electron microscope. The microscopy was performed in accordance with the ASTM D1413-48 of 1983 and ASTM D1413-61 procedure of 2007.

Fibre Measurement

The macerated fibres were placed on a slide (standard, 7.5cm x 2.5cm) by means of a medical dropper. All the characteristics namely, fibre length, diameter, lumen width and cell wall thickness were viewed under Zeiss light microscope in swollen state.

i. Fibre length: This is the number of bonding available on an individual fibre to form an inter woven network of fibres
ii. Fibre Diameter: This is the diameter of fibre measured from side to side end to end side. It is measured across the fibre length. It is the transvers direction of the fibre
iii. Lumen Size: This is the diameter of the internal cavity. It is measured in a transverse direction.
iv. Fibre Wall Thickness: The proportion of cell wall varies in trees. The thickness of cell wall is considerably determined by the age of the tree. It has been shown that juvenile wood fibres are thin walled while others or over matured have thick walled fibres. This underline why slenderness and thin wall fibre collapse easily into matrix than thick walled fibre from mature wood.

$$Fibre\ wall\ thickness = Fibre\ diametre - Lumen\ size \ldots\ldots\ldots\ldots\ldots (1)$$

Determination of Fibre Suitability

Three derived morphological indices was calculated based on method adopted by Saika *et al.*, (1997), Ogbonnaya *et al.* (1997), Ververis *et al*. (2004), Oluwadare and Sotannde (2006) and Tutus *et al.* (2010). These include:

i. Felting power:

$$Felting\ power = \frac{Lumen\ width}{Fibre\ diameter}\ x\frac{100}{1} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

ii. Runkel ratio: Is a parameter used to determine the suitability of a material for pulping. When it is greater than 1 the materials is considered unsuitable for papermaking and vice versa.

$$Runkel\ ratio = \frac{2\ x\ cell\ wall\ thickness}{lumen\ width} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

iii. Co-efficient of suppleness: This give the tensile strength and bursting strength or corresponding bursting l/d ratio is linked to the tearing resistance of paper.

$$Coefficient\ of\ Suppleness = \frac{Cell\ wall\ thickness}{Fibre\ diameter}\ x\frac{100}{1} \ldots\ldots\ldots\ldots\ldots (4)$$

RESULTS AND DISCUSSION

Fibre Measurement

The result in table 1 showed the variation in root, stem, leaf and flower fibre length of the plants. *Hibiscus cannabinus* has the longest stem fibre length of 1.02mm, *Hibiscus sabdarrifa* have the stem fibre length of 0.96mm while *Duranta repens* have the stem fibre length of 0.84mm. This is contrary to Osadare and Udohitinah (1993) who gave the stem fibre length of *Hibiscus cannabinus* to be 2.90mm and *Hibiscus sabdarrifa* to be 2.65mm. Loveth, 2005 recorded the stem fibre length of *Duranta repens* to be 1.88mm also at variance to the value above. This may likely be due to location difference and environmental factors.

Table 1: Variation in fibre length, diameter, lumen width and cellwall thickness at the root, stem, leaf and flower

Parameters Determined	**Plant part**	***Hibiscus sabdarrifa***	***Hibiscus cannabinus***	***Duranta repens***
Fibre length(mm)	Root	0.71	1.43	0.60
	Stem	0.96	1.02	0.84
	Leaf	0.63	0.65	0.59
	Flower	0.53	0.71	-
Fibre diameter(mm)	Root	0.05	0.06	0.05
	Stem	0.05	0.06	0.04
	Leaf	0.05	0.05	0.05
	Flower	0.05	0.05	-
Lumen width (mm)	Root	0.03	0.03	0.03
	Stem	0.03	0.03	0.03
	Leaf	0.03	0.03	0.03
	Flower	0.03	0.01	-
Fibre wall thickness (mm)	Root	0.01	0.01	0.01
	Stem	0.01	0.01	0.01
	Leaf	0.01	0.01	0.01
	Flower	0.01	0.01	-

Fibre Suitability

From Table 2 below, runkel ratio of *Hibiscuss cannabinus* is 0.83mm and *Hibiscus sabdarrifa* is 0.58mm while *Duranta repens* is 0.85mm. According to Osadare and Udohitinah 1993 who gave runkel ratio of *Hibiscus canabinus* to be 0.76mm and *Hibiscus sabdarrifa* to be 0.59mm while loveth 2005 gave the runkel ratio to *Duranta repens* to be 0.95mm.

T**able 2: Summary of derived fibre characteristics**

Parameters	Plant part	*Hibiscus sabdarrifa*	*Hibiscus cannabinus*	*Duranta repens*
Runkel ratio	Root	0.89	0.79	0.83
	Stem	0.58	0.83	0.85
	Leaf	0.59	0.67	0.82
	Flower	0.95	0.83	-
Coefficient of suppleness	Root	0.62	0.54	0.54
	Stem	0.56	0.52	0.57
	Leaf	0.57	0.54	0.54
	Flower	0.60	0.52	-
Felting power	Root	14.16	25.50	12.5
	Stem	20.08	16.93	18.95
	Leaf	13.74	13.50	12.80
	Flower	10.56	13.19	-

All these values were very similar to previous work and it confirms that these species are suitable for pulp and paper making since the runkel ratio is less than one. It was observed that *Hibiscus cannabinus* have a higher value in fibre length than *Hibiscus sabdarrifa*.

Graph 1: Compares the stem of the various wood species

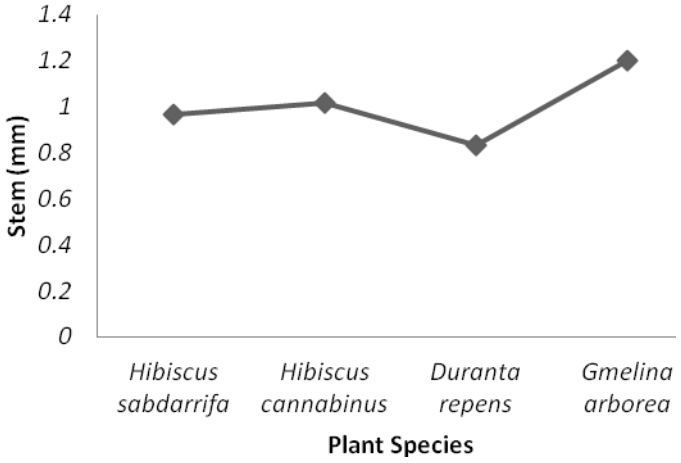


Table 3: Shows the Analysis of Variance of the Plant parts (Leaves, Stem, Root and Flower

SV	SS	Df	MS	Fcal	Sig
Leaves					
Treatment	0.0132	2	0.0091	0.1664	Ns
Error	1.4779	27	0.0547		
Total	1.4961	29			
Stem					
Treatment	0.177	2	0.0885	0.799	Ns
Error	2.992	27	0.1108		
Total	3.169	29			
Root					
Treatment	4.0396	2	2.0198	36.79	*
Error	1.4825	27	0.0549		
Total	5.5221	29			
Flower					
Treatment	0.169	1	0.169	2.637	Ns
Error	1.1544	18	0.641		
Total	1.3234	19			

ns=Not significant, *=significant *p*=0.05, SV=Source of variation, ss=Sum of Squre, Ms=Mean Square, Df=degree of freedom

As clearly seen in graph 1, *Gmelina arborea* was compared with Kenaf and it was observed that *Gmelina arborea* have longer fibre length of 1.2mm followed by *Hibiscus cannabinus* of 1.02mm and *Hibiscus sabdarrifa* of 0.96mm, so also *Duranta repens* of 0.83mm. *Gmelina arborea* in this case have longer fibre length than the plants above. The test of significant among the various parts of the plant shows that there is no significant difference in the leave, stem and flower but the root are significantly different from each other at *p=0.05*

CONCLUSION

In this study, preliminary fibre characteristics of *Hibiscus sabdarriffa*, *Hibiscus cannabinus* and *Duanta rapens* were determined; it was observed that they were all less than that of *Gmelina arborea* wood. However, the runkel ratio of *Hibiscus sabdrriffa*, *Hibiscus cannabinus* and *Duranta rapens* which are 0.58, 0.83 and 0.85, respectively indicated that they were all suitable for pulp and paper making.

REFERENCES

Akpabio, U. D. and Akpkpan, A. E. (2012). Pulp and paper from agricultural wastes: plantain pseudostem wastes and screw pine leaves. *Int. Jour. of Modern Chemistry*. 2 (3): 100-107.

Ates, S., Ni, Y., Akkgul, M. and Tozluoglu, A. (2008). Characterization and evaluation of Paulownia elongate as a raw material for paper production. *African Jour. Biotechnol*. 7(22):4153-4158.

Anuar H. and Zuraida A. (2011): Improvement in mechanical properties of reinforced thermoplastic elastomer composite with kenaf bast fibre. *Compos Part B Eng.* Vol. 42, pp. 462-65.

Davoodi MM, Sapuan SM, Ahmad D., Ali A., Khalina A. and Jonoobi M. 2010. Mechanical properties of hybrid kenaf/glass reinforced epoxy composite for passenger car bumper beam. Mater Des Vol. 31, pp. 4927-32.

Elanchezhian .C, Vijaya Ramnath B, Kaosik R., Nellaiappan T. K., Santhosh Kumar K., Kavirajan P. and Sughan M. U (2015): Evaluation Of Mechanical Properties Of Kenaf Based Hybrid Composite for Automotive Components Replacement. *ARPN Journal of Engineering and Applied Sciences.*, Vol. 10, No. 13, July 2015. ISSN 1819-6608.

Hazizan Md Akil, ZA. Mohd Ishak, Leong Wei Cheng, A. Abu Bakar and M. A. AbdRahman (2009): Water Absorption Study on Pultruded Jute Fiber Reinforce Unsaturated Polyester Composite, Composites Sciences and Technology 691942-1948.

Mclaughlin S.P. and Schuck, S.M. (1991). Intraspecific variation in fibre properties in Yucca elata and Hesperaloe funifera (Agavaceae). *Economic Botany* 46(2): 181-186.

Nishino T., Hirao K., Kotera M., Nakamae K. and Inagaki H. (2003): Kenaf reinforced biodegradable composite. *Compos Sci Technol*, Vol. 63, pp. 1281- 86.

Ogbonnaya, C.I., Roay-Macauley, H., Nwalozie, M.C. and Annerose, D.J.M. (1997): Physical and histochemical properties of kenaf (Hibiscus cannabinaus L.) grown under water deficit on a sandy soil. *Ind.Crops Prod*. 7: 9-18. rious solutions, Materials and Design, Vol. 31, pp.4960-4964.

Ogunsile, B.O., Omotoso, M.A. and Onilude, M.A. (2008). Pulp and Paper potentials of plaintain pseudostem *J. of Sci. and Technol*. 28(3):159-165.

Oluwadare, A. O. and Sotannde, O. A. (2006): Variation of the fibre dimensions in the Stalks of Miraculous berry (*Thaumatococcus danielliiBenth). Production Agricultural Technology (PAT),* Vol. 2(1):85-90.

Paukszta D. and Borysiak S. (2013): The influence of processing and the polymorphism of lignocellulosic fillers on the structure and properties of composite materials – A review. *Materials* (Base), Vol. 6, pp. 2747-67.

Raman Bharath V. R,Vijaya Ramnath B. and Manoharan N. (2015): Kenaf Fibre Reinforced Composites: A Review. *ARPN Journal of Engineering and Applied Sciences.* Vol. 10, No. 13, July 2015.

Ravetta, D.A and Mclaughlin, S.P. (1996). Ecophysiological studies in Hesperaloe funifera (Agavaceae): a potential new CAM crop. The effect of light availability on photosynthesis and growth. *Jour. Arid Environ.* 33:399-407.

Saika, S. N., Goswami, T. and Ali, F. (1997): Evaluation of pulp and paper making characteristics of certain fast growing plants. *Wood Sci*. Technol. 31:467-475.

Slideshare (2010). Classification of fibre. (www.slideshare.net/kanniks/classification accessed on 07/03/2014), 8pp.

Tutus, A. Comlekcioglu, N., Karaman, S. and Alma, M.H. (2010): Chemical composition and fibre properties of *Crambe orientalis* and *C. Tataria*. *Int. J. Agric. Biol.* Vol. 12 (2): 1814-9596.

Udohitinah, J.S. and Oluwadare, A.O. (2011). Pulping properties of Kraft pulp of Nigeria grown Kenaf (*Hibiscus canabinus* L). *BioResources* vol. 6 (1):751-761.

Ververis, C., Georghiou, K.,Christodoulakis, N., and Santas R. (2004): Fibre dimensions, lignin and cellulose content of various plant materials and their suitability for paper production. *Ind. Crops prod*. 19:245-254.

Wang, Jinhua and Ramaswamy ,G.N. (2003): One-step processing and bleaching of mechanically separated kenaf fibers: effects on physical and chemical properties *Text Res J.*, Vol. 73, pp. 339-344.

Zhu J., Zhu H., Njuguna J. and Abhyankar H. (2013): Recent development of flax fibers and their reinforced composites based on different polymeric matrices. *Materials* (Base), Vol. 6, pp. 5171-98.

Different Pre-Treatment Method Effects on the Production of Wood Cement Boards from *Nauclea diderrichi*

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ABSTRACT

The study examined the effect of different pre-treatment methods on suitability and dimensional stability of cement bonded particle board production from sawdust of Nauclea diderichii. The production variables investigated were sawdust soaked in cold water for 24 hour, 1 hour hot water soak and both combination Each of the three pretreatment made use of two chemical additives, $cacl_2$ and $Fecl_3$ which was based on two concentration levels 3% and 4%.. A combination of 2x2x3 treatment combination to give 12 boards and replicated five times were subjected to dimensional stability test of water absorption (WA) and thickness swelling (TS) and Modulus of rupture and elasticity. From the results obtained, Mean Modulus of Rupture values ranged from 5.81 to 15.98N/mm^2, Modulus of elasticity ranged from 2750 to 4800N/mm^2 and Water Absorption and Thickness Swelling values ranged from 9.63 to 13.84 and 0.41 to 3.56% respectively. A more dimensionally stable board was also produced at an increasing chemical additive concentration. Stronger, stiffer and more dimensionally stable boards were produced from the use of $Fecl_3$ as additive against $cacl_2$. The production of dimensionally stable board is possible with Nauclea diderichii sawdust.

Keywords: Modulus of elasticity, modulus of rupture, thickness swelling, water absorption and additives

INTRODUCTION

Wood cement based composites refers to a family of engineered wood panels that include panelboards, fibreboards and hardboards. Wood cement composites is a combination of wood raw material such as flakes, sawdust with inorganic binder such as additives, water and cement. Wood cement boards (WCB) are already used thoroughly in Europe, United States, Russia and Asia mainly for roofs, floors, walls and so on. They possess countless advantages compared to panels produced with organic resins which are high durability, good dimensional stability, acoustic and thermal insulation properties and low cost of production.

In recent years, several research groups have been evaluating the suitability of different lignocellulosic materials for the manufacture of WCB including cypress (Okine *et al*, 2005) rubberwood (Okine *et al*, 2004) Eucalyptus (Okine *et a*l 2004) there are obstacles to the utilization of these materials for Wood cement boards, the main problems are the inhibitory effects caused by wood on the cure of cement and the high density of the final product. Wood components mainly extractives and polysaccharides affects reactions between wood and cement which results in low quality boards. Jorgue *et al* 2004 argued that the nature of the extractives has influence on these inhibitory effects. To solve inhibitory effects problems, it is common to add inorganic chemicals known as accelerators to accelerate the cure of the cement or use pretreatment such as aqueous extraction to remove inhibitory substances from wood. Cement chemicals accelerators usually improve the properties of WCB Jorge *et al* 2004) according to Jorgue *et al* (2006), one of the most promising additives for the WCB industry is silica fume (SiO2). Silica fume is a pozzolan material based on silica and aluminum with little cement properties; it is an industrial by products of metallic silicon in fine powder form and in presence of water. It reacts chemically with calcium hydroxide to form cement. Portland cement produces about 20% calcium hydroxide; the substitution of cement with silica fume in concrete applications minimizes exudation and increases cohesion and resistance to cohesion. Some WCB utilize large amount of cement compared to wood thereby resulting in high density boards. Therefore it will be desirable to develop a low density board using larger amount of wood, reducing the wood cement ratio. This paper examined the effect of different pretreatment methods on suitability and dimensional stability of cement bonded particle board production from sawdust of *Nauclea diderichii.*

MATERIALS AND METHODS

The materials used for the study was sawdust and shavings of *Nauclea diderichii*, Portland cement, additives and water. Sawdust of *Nauclea diderichii* was collected in Forests Products Development and Utilization, Forestry Research Institute of Nigeria (FRIN), sieved to remove coarse particles sizes and was pretreated inside water soaked in cold water for 24 hour, 1 hour hot water soak and both combination Each of the three pretreatment made use of two chemical additives, $cacl_2$ and $Fecl_3$ at two concentration levels 3% and 4% to improve the bonding between the cement and the wood..

Board Formation and Testing

Sawdusts of *Nauclea diderichii* was mixed with Portland cement, Calcuim chloride and iron chloride were added to the mixture to accelerate hardening. The final mixture was spread into an open mould caul plate to form a mat of uniform thickness. The mat was compressed later to 1.00cm in a pressing machine at room temperature and pressure of 4N/mm2 for 15 hours for cement hydration and hardening. The boards were trimmed and tested for thickness swelling (TS) and water absorption (WA) manually after six days of further curing at the Wood Anatomy Laboratory, Forestry Research Institute of Nigeria. Samples were also taken to the Timber Mechanics section, Forestry Research Institute of Nigeria for Modulus of Rupture and Elasticity. A combination of 2x2x3 treatment combination to give 12 boards replicated five times were subjected to dimensional stability test of water absorption (WA) and thickness swelling (TS) and Modulus of rupture and elasticity. The specimen used for dimensional stability tests were 50mm x 50mm x 6mm,the thickness of the test specimens were measured with a dial gauge to ascertain the thickness of the weight was determined according to the British standard 373 (1989). The specimens were later removed and drained for 10 minutes to remove excess water, therefore, specimens were weighed and thickness measurement taken. Water absorption was calculated from the increase in the specimen as follows:

$$WA\% = \frac{W2 - W1}{W1} \times 100$$

Where:

WA = water absorption (%)
W2= final weight after treatment (g)
W1= initial weight after treatment (g)

$$TS\% = \frac{T2 - T1}{T1} \times 100$$

Where:

TS= thickness swelling (%)
T2=final thickness after treatment (mm)
T1= initial thickness after treatment (mm)

Modulus of Rupture (MOR)

Board samples were cut into 12mmx 50mm x 178mm dimension according to the British standard 373(1989) and tested on an elastic beam apparatus. The loads were applied until failure of the sample occurred. The load at which each text sample failed was recorded. The MOR was calculated using the formula.

$$MOR = \frac{3PL}{2bd^2}$$

Where:

MOR= Modulus of rupture (N/mm^2)
P=load (N)
L= the span of board sample between the machine supports (mm)
b= width of the board sample (mm)
d= thickness of the board sample (mm)

Modulus of Elasticity (MOE)

The modulus of elasticity was calculated from the values obtained from the load deflection graph during the test for MOR. The formula employed is given as MOE

$$= \frac{PL^3}{4bd^3h}$$

Where:

MOE= modulus of elasticity (N/mm^2)
P= load (N)
L= The span of board sample between the machine supports (mm)
b= width of the board sample (mm)
d= thickness of the board sample (mm)
h= slope from the graph.

RESULTS AND DISCUSSION

Modulus of Rupture (MOR)

Modulus of rupture values obtained is presented in Table1 which ranged from 5.81 to 15.98N/mm2, the mean values compared favorably to findings from research from Badejo 1998 and Fuwape 1995.

Table 1: Mean values of MOR for the treatments

Pre treatment	Additives	Concentration	Mean MOR
24 hours cold soak	$Cacl^2$	3	5.84
24 hours cold soak	$Cacl^2$	4	6.31
24 hours cold soak	$Fecl_3$	3	5.81
24 hours cold soak	$Fecl_3$	4	6.01
1 hour Hot water	$Cacl^2$	3	10.99
1 hour Hot water	Cacl2	4	12.32
1 hour Hot water	Fecl3	3	10.91
1 hour Hot water	Fecl3	4	12.04
Cold + Hot	Cacl2	3	13.16
Cold + Hot	Cacl2	4	15.98
Cold + Hot	Fecl3	3	12.87
Cold + Hot	Fecl3	4	15.55

The influences of the three production variables used in the study on static bending, strength are shown in Figure 1. Based on the findings on this research, it was observed that one hour hot water was effective in extraction of chemical substance in *Nauclea diderichii* sawdust.

Modulus of Elasticity (MOE)

The results of MOE test carried out are listed in Table 2. Mean values of Modulus of Elasticity range from 2750 to 4800N/mm2. The influence of the three variables used in the study on static bending of the boards is shown in figure 2. The trend of response to stiffness property to the production variables is similar to that of the boards.

Table 2: Mean values of MOE for the treatments

Pre treatment	Additives	Concentration	Mean MOE
24 hours cold soak	Cacl2	3	2800
24 hours cold soak	Cacl2	4	3370
24 hours cold soak	Fecl3	3	2750
24 hours cold soak	Fecl3	4	2860
1 hour Hot water	Cacl2	3	3500
1 hour Hot water	Cacl2	4	4010
1 hour Hot water	Fecl3	3	3510
1 hour Hot water	Fecl3	4	3570
Cold + Hot	Cacl2	3	4400
Cold + Hot	Cacl2	4	4800
Cold + Hot	Fecl3	3	4460
Cold + Hot	Fecl3	4	4530

Based on findings on this research, boards produced from combination of 24hours water soaking and one hour hot water soaking at 80oC was stiffer in bending than the other two variables. Results from this research conform favorably with findings from past research of Fuwape 1995 Ajayi,2006, Ajayi and Aina, 2012.

Water Absorption (WA) and Thickness Swelling (TS)

These two parameters (WA & TS) measure the dimensional stability of particle boards as presented in Table 3 and 4. Water Absorption and Thickness Swelling of the boards ranged from 9.63 to 13.84% and 0.41 to 3.56% respectively following 24hours soak in water. The results also conform to findings from Fuwape 1998, Ajayi,2006, Ajayi and Aina, 2012. The influences of the production variables on mean Water Absorption and Thickness Swelling values are represented in figure 3 and 4. The lowest mean Water Absorption value of 9.63% and Thickness Swelling of 0.41% emanated from boards made with combined treatment.

Table 3: Mean values of WA for the treatments

Pre treatment	Additives	Concentration	Mean WA
24 hours cold soak	Cacl2	3	13.84
24 hours cold soak	Cacl2	4	13.08
24 hours cold soak	Fecl3	3	13.77
24 hours cold soak	Fecl3	4	12.74
1 hour Hot water	Cacl2	3	12.33
1 hour Hot water	Cacl2	4	11.86
1 hour Hot water	Fecl3	3	12.01
1 hour Hot water	Fecl3	4	11.17
Cold + Hot	Cacl2	3	11.18
Cold + Hot	Cacl2	4	10.22
Cold + Hot	Fecl3	3	11.00
Cold + Hot	Fecl3	4	9.63

Table 4: Mean values of TS for the treatments

Pre treatment	Additives	Concentration	Mean TS
24 hours cold soak	Cacl2	3	3.56
24 hours cold soak	Cacl2	4	3.00
24 hours cold soak	Fecl3	3	3.12
24 hours cold soak	Fecl3	4	2.51
1 hour Hot water	Cacl2	3	2.10
1 hour Hot water	Cacl2	4	1.75
1 hour Hot water	Fecl3	3	1.86
1 hour Hot water	Fecl3	4	1.02
Cold + Hot	Cacl2	3	0.56
Cold + Hot	Cacl2	4	0.31
Cold + Hot	Fecl3	3	0.43
Cold + Hot	Fecl3	4	0.41

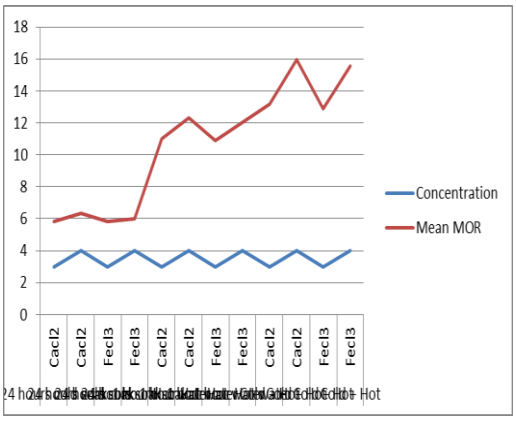


Figure 1

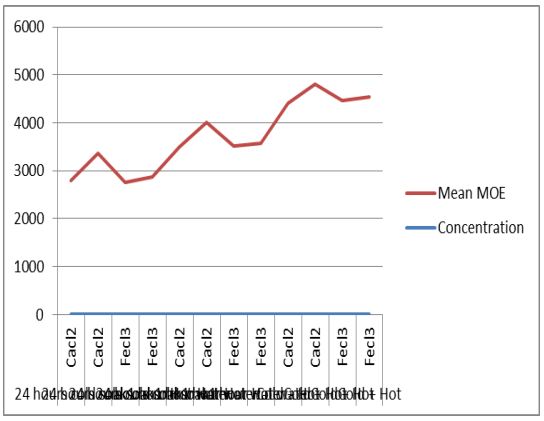


Figure 2

Figure 1: Influence of pre treatment type on Modulus of Rupture at Concentration level
Figure 2: Influence of pre treatment type on Modulus of Elasticity at Concentration level

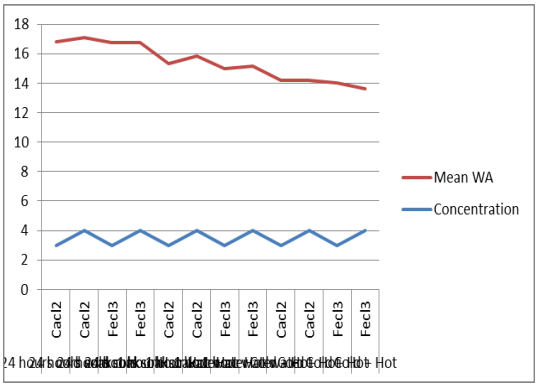


Figure 3

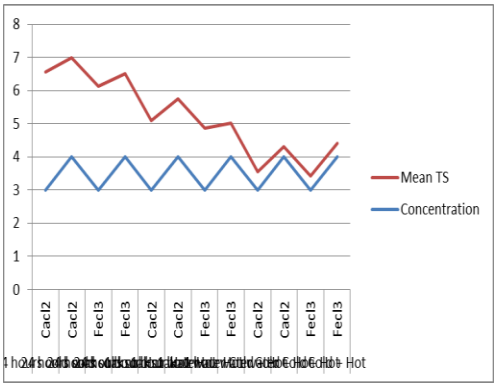


Figure 4

Figure 3: Influence of pre treatment type on Water Absorption at Concentration level
Figure 4: influence of pre treatment type on Thickness Swelling at Concentration level

CONCLUSION

In conclusion the production of wood cement boards from *Nauclea diderichii* is possible and the species is suitable for wood cement board production. The boards made at concentration level of 4% were stronger, stiffer and more dimensionally stable. The lowest mean Water Absorption value of 9.63% and Thickness Swelling of 0.41% emanated from boards made with combined treatment. Boards produced from combination of 24hours water soaking and one hour hot water soaking at 80^{o}C was stiffer in bending than the other two variables.

REFERENCES

Aina, *et al* (2012): Comparative Study on Properties of Wood Plastic Composite produced from Coffee chaff and *Ceiba petandra* sawdust, Proceedings 3rd Conference in Forest and Forest Products, 3 - 6th April 2012, Ibadan Nigeria

Ajayi, B (2006): Properties of Maize Stalk based Cement bonded composites, Forest Products Journal Vol56, (6): Pp 51 - 55

Badejo, S.O.O 1989: Influence of pretreatment and additive concentration on the properties of cement bonded boards. Tropical hardwood tropical Science 1989, 29;285-298

Fuwape, J.A 1995: The effect of cement wood ratio on the strength properties of cement bonded particleboard from spruce. Journal of Tropical Forest Products 1:49-58

Jorge, F.C; Pereira, C;Ferriera, J.M.F 2004: Wood Cement composites;ma review.Holz als Rohund Werkstoff 62; 320- 377

Okino, E.Y.A;De Souza, M.R; Santana, M.A.E; Da Alves, M.V.; De Souza,M.E., Texeira, D.E 2004: Cement bonded wood particleboard with a mixture of eucalyptus and rubberwood. Cement and Concrete Composites 26, 729-734

Okino, E.Y.A;De Souza, M.R; Santana, M.A.E; Da Alves, M.V.; De Souza,M.E., Texeira, D.E 2005: Physiomechanical properties and decay resistance of Cupressus spp. Cement bonded particleboards. Cement and Concrete Composites 27, 333 – 338

Olufemi A. Sotande, Abiodun O, Oluwadare O,O Adeogun (2012) Evaluation of cement bonded particle board produced from Afzelia wood residues. Journal of Enginering Science and Technology Vol 7, No 6(2012) 732 – 743.

Systematic Wood Anatomy of Selected Wood Species of Castilleae and Moreae Tribes

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ABSTRACT

Anatomical features of Milicia excelsa and Morus mesozygia both from Moreae tribes, as well as Antiaris toxicaria, A.welwitschii and A.africana from Castilleae tribe were investigated in this study. Wood samples were cut into thin sections of about 20µm thick using a Reichet sliding microtome. Staining was done by covering the sections with safranin red solution, and wood cells were observed under a light microscope upon which a digital camera was mounted to photograph anatomical features. Wood species from the two tribes were separated on the account of rays, vessels and inclusions such as rays. Diagnostic features such as prismatic crystals were well pronounced in Morea tribe but were not present or rare in the Castilleae tribe. Septate fibres and sheath cells were mostly present in Castilleae tribe, the features which were not noticeably present in Moreae tribe. Within each tribe, wood species could be identified on the basis of certain microscopic features such as distribution of the axial parenchyma cell which were conspicuously banded more in Morus mesozygia than in Melicia excelsa; crystals were also more abundant in the wood than in Melicia excelsa . These features indicated that even within each tribe there are anatomical features which show that wood species can still be separated whenever a need for identification arises during instances of wood adulteration. Wood micrographs which reflect areas of similarity and differences in wood micro structures were also presented.

Keywords*:* Castilleae, Moreae, rays, vessels, diagnostic, tribes

INTRODUCTION

The tribes Castilleae and Moreae belong to the same family Moraceae often called the mulberry or fig family in the order Rosales (Sytsma et al, 2002). Moraceae family is divided into six tribes namely Artocarpeae, Moreae, Maclureae, Dorstenieae, Castilleae and Ficeae (Ribeiro, 2007; Clement and Weiblen, 2009). This study forms a part of a series of investigations into all the tribes within the Morareae family even though the tribe Ficeae had been studied in Nigeria extensively among wood species in its genus Ficus L (Ogunkunle and Oladele, 2008; Adeniyi *et al*., 2013).

Moreae tribe has about 10 genera among which are Milicia Sim. and Morus L. that are represented in Nigeria by *Milicia excelsa* and *Morus mesozygia*. Meanwhile, Castilleae tribe contains more than 11 genera including the genus Antiaris Lesch and is represented in Nigeria by *Antiaris toxicaria* var. *welwitschii* and var. *africana*; the two varieties growing in Nigeria namely *Antiaris toxicaria* and var. *africana* are much alike in habitat, but they can be readily distinguished by their leaves (Keay, 1989). Trees in Castilleae and Moreae tribes have a common feature of latex in all parts of the plant, and this feature has made some of the species within the family useful. For instance, latex from *Antiaris toxicaria* is applied to cuts, wounds and skin complaints such as eczema and leprosy, and is taken internally as a purgative. It is also reported to be used as a fish poison and birdlime (Cement and Weiblen, 2009) as well as a mild circulatory and cardiac stimulant when used in very small amounts, but in large amounts it is a myocardial poison; latex from *Milicia excelsa* is applied on burns, wounds, sores and against eczema and other skin problems. It is also taken against stomach problems, hypertension and as a galactagogue, and it is used for treatment of tumours and obstructions of the throat (Ofori, 2007), while latex from *Morus mesozygia* is also used for making birdlime and has been used as a rubber adulterant. Apart from the common latex within the tribes, other similarities do occur: *Antiaris africana* rather resembles *Milicia excelsa* (Iroko) in its dark foliage, but its branches are more horizontal, perhaps the reason why it is often called "false Iroko (*Milicia excelsa*)." Within the tribe of Moreae, the wood of *Morus mesozygia* resembles that of iroko (*Milicia excelsa* (Welw.) C.C.Berg) and it has sometimes been exploited as such (Toirambe and Ouattara, 2008), but it has a finer texture. The wood properties of *Milicia excelsa* are also similar to those of teak. Even *Antiaris toxicaria* is said to also resemble *Triplochiton scleroxylon* K.Schum. and could be used as a substitute for *Terminalia*

superba Engl. & Diels and *Pterygota macrocarpa* K.Schum. In spite of all this, different species from the same genus still have different properties and perform differently under various conditions owing to their different histological features.

Though the wood species in the two tribes have been noted for interior joinery, panelling, moulding, furniture, strip flooring, boxes, crates, tool handles, toys, carvings, peeled and sliced veneer; others are canoes, drum making, sporting goods, shipbuilding, sleepers, novelties, posts, poles, piles, mine props and shingles, serious problems can therefore develop if species or genera are mixed during the manufacturing process and in use (Wiedenhoeft and Miller, 2002) especially when underlying microstructures are ignored. Therefore, identifying wood is of critical importance to primary and secondary industrial users of wood, government agencies, and museums, as well as to scientists in the fields of botany, ecology, anthropology, forestry, and wood technology. This study therefore compares the microscopic features of some of the wood species of Moreae and Castilleae tribes within the Moraceae family in order to separate them on the basis of their anatomical properties. This in turn will reduce incidents of 'adulteration' during wood utilization.

MATERIALS AND METHODS

Wood samples were obtained from matured trees of *Antiaris africana*, *A. toxicaria*, *A. welwitschii* (Moreae tribe), *Milicia excels* and *Morus mesozygia* (Castilleae tribe) from South western part of Nigeria at Onigambari Forest Reserve located between Latitude 7º 8'3"N and Longitude 3º 49′22"E in Ibadan South Western Nigeria, this area has an average annual rainfall between the range of 800 mm in the derived eco-zone to 1500 mm in the rainforest belt. The annual rainfall is bimodal with its peak in July and September (Faleyimu and Agbeja, 2004), with a mean annual temperature of 24-30ºC. The trees were harvested and processed into 1 cm^3 wood test samples, the wood microscopy was performed in accordance with the ASTM D1030-95 procedure of 2007 and ASTM D1413-61. Thin sections of about 20µm thick were cut in three planes namely cross sectional, tangential and radial sections using a microtome sliding machine. Staining was done by covering the sections with safranin red solution. Wood cells were observed under a light microscope; measurement of wood microscopic features was performed using a stage micrometer mounted on the light microscope at 80 ×. A digital camera on a light microscope was used to photograph anatomical features. Nomenclature and cell sizes were determined following microscopic terminology for hardwood identification (IAWA Committee 1989).

RESULTS

Castillaeae Tribe

Antiaris toxicaria

The heartwood was whitish to yellow-brown and not distinctly demarcated from the sapwood. The wood of *Antiaris toxicaria* is lightweight with the density ranging between 370–480 kg/m³ at 12% moisture content. The grain was interlocked to wavy while the texture was moderately coarse. The mcisroscopic anatomy of the wood is as follow: 2: growth ring boundaries indistinct or absent. Vessels: 5: wood diffuse-porous;9: predominantly solitary 22: intervessel pits alternate, and gash like; 32: vessel-ray pits are gash like; 43: mean tangential diameter of vessel lumina was greater than 200 µm, it was about 234 µm on the average; 65: septate fibres present; 69: fibres thin- to medium walled. 79: axial parenchyma vasicentric; 80: axial parenchyma aliform; 92: Rays: 98: larger rays commonly 3-6 seriate; heterogeneous type III; 106: body ray cells procumbent with one row of upright and/or square marginal cells; 107: body ray cells procumbent with mostly 2–4 rows of upright and/or square marginal cells; 110: sheath cells present); 124: oil and mucilage cells associated with ray parenchyma; 132: laticifers or tanniferous tubes.

Antiaris Africana

The heartwood was basically yellow to white or grey brown to yellow. Sapwood colour similar to heartwood colour. Density 400-500 kg/m³. Grain was interlocked. Growth ring;2: growth ring boundaries indistinct or absent. Vessels: 5: wood diffuse-porous; 9: predominantly solitary, though radial multiples of 2-3 were present; 22: intervessel pits alternate, and gash like; 32: vessel-ray pits are gash like; 42: mean tangential diameter of vessel lumina 100–200 µm, it was about 187µm on the average; 61: fibres with simple to minutely bordered pits; 65: septate fibres present; 69: fibres thin- to medium walled. Axial parenchyma: 79: axial parenchyma vasicentric; 80: axial parenchyma aliform; 92: Rays in echelon: 98: larger rays commonly 3-6 seriate; heterogeneous type III; 106: body ray cells procumbent with one row of upright and/or square marginal cells; 107: body ray cells procumbent with mostly 2–4 rows of upright and/or square marginal cells; 110: sheath cells present; 132: laticifers or tanniferous tubes.

Antiaris welwitschii

Growth ring, 2: growth ring boundaries indistinct or absent. Vessels: 5: wood diffuse-porous;9: predominantly solitary; 22: intervessel pits alternate, and gash like; 32: vessel-ray pits are gash like; 42: mean tangential diameter of vessel lumina 100–200 µm, about 192 µm in average; 61: fibres with simple to minutely bordered pits; 65: septate fibres present; 69: fibres thin- to medium walled. Axial parenchyma: 79: axial parenchyma vasicentric; 80: axial parenchyma aliform; 92: Rays: 98: larger rays commonly 3-6

seriate, and in echelon; heterogeneous type III; 106: body ray cells procumbent with one row of upright and/or square marginal cells; 107: body ray cells procumbent with mostly 2–4 rows of upright and/or square marginal cells; 110: sheath cells present. 124: oil and mucilage cells associated with ray parenchyma; 132: laticifers or tanniferous tubes.

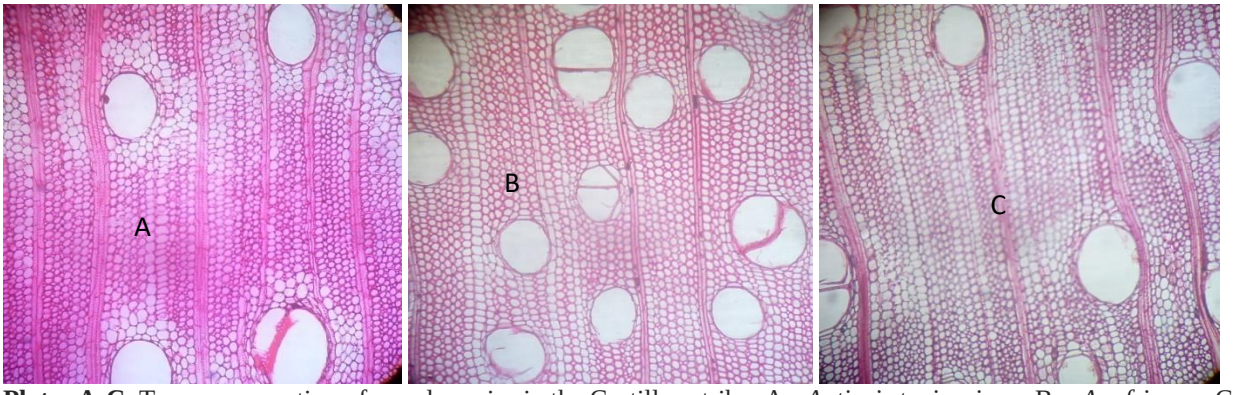
Moreae Tribe

Milicia excelsa

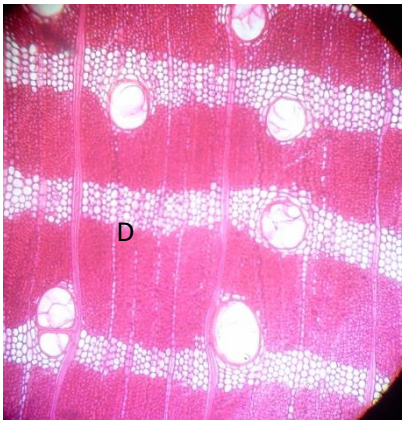
The heartwood is pale yellow to yellow, darkening on exposure to yellowish or greenish brown or sometimes to chocolate brown; the grain is interlocked, The wood density was within 550 to 750 kg/m³ at 12% moisture content. Growth rings: 2: growth ring boundaries indistinct or absent. Vessels: 5: wood diffuse-porous; 9.1: vessels in short radial multiples 2-3; 13: simple perforation plates; 22: intervessel pits alternate; 23: shape of alternate pits polygonal; 3 2: intervessel pits gash-like; 30: vessel-ray pits with distinct borders; similar to intervessel pits in size and shape throughout the ray cell ; 32: vessel-ray pits with much reduced borders to apparently simple: pits horizontal (scalariform, gash-like to vertical (palisade); 43: mean tangential diameter of vessel lumina ≥ 200 μm, it was about 255.6 μm on the average; 56: tyloses common. Tracheids and fibres: 61: fibres with simple to minutely bordered pits; 66: non-septate fibres present; 69: fibres thin- to thick-walled. Axial parenchyma: 80: axial parenchyma aliform; 83: axial parenchyma confluent; 84: axial parenchyma unilateral paratracheal); 98: larger rays commonly 4- to 10-seriate, rays in echelon and heterogeneous type III; 106: body ray cells procumbent with one row of upright and/or square marginal cells; 107: body ray cells procumbent with mostly 2–4 rows of upright and/or square marginal cells); 132: laticifers or tanniferous tubes. Mineral inclusions: 136: prismatic crystals present; 137: prismatic crystals in upright and/or square ray cells; 141: prismatic crystals in non-chambered axial parenchyma cells.140: prismatic crystals in chambered upright and/or square ray cell.

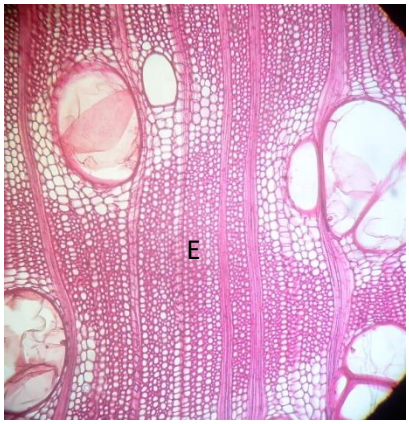
Morus mesozygia

The heartwood is yellow when freshly cut, darkening to brown on exposure, and distinctly demarcated from the sapwood with a density of 660–920(–1050) kg/m³ at 12% moisture content. The texture is fine to medium; the grain is straight to interlocked; growth rings: 2: growth ring boundaries indistinct or absent. Vessels: 5: wood diffuse-porous; 9: vessels exclusively solitary; 9.1: vessels in short radial multiples; 13: simple perforation plates; 25: inter-vessel pits small; 30: vessel-ray pits similar to intervessel pits 42: mean tangential diameter of vessel lumina 100–200 μm, about 148 μm on the average; 56: tyloses common; 66: non-septate fibres present; 69: fibres thin- to thick-walled; 76: axial parenchyma diffuse; 83: axial parenchyma confluent; 85: axial parenchyma bands more than three cells wide; Rays: 97: ray width 1–3 cells, heterogeneous type II; rays in echelon; 106: body ray cells procumbent with one row of upright and/or square marginal cells;132: laticifers or tanniferous tubes; 136: prismatic crystals present; 137: prismatic crystals in upright and/or square ray cells; 141: prismatic crystals in non-chambered axial parenchyma cells.

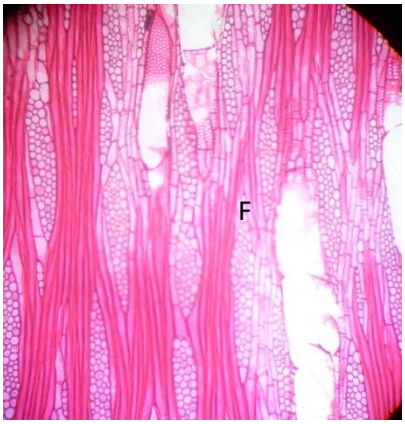


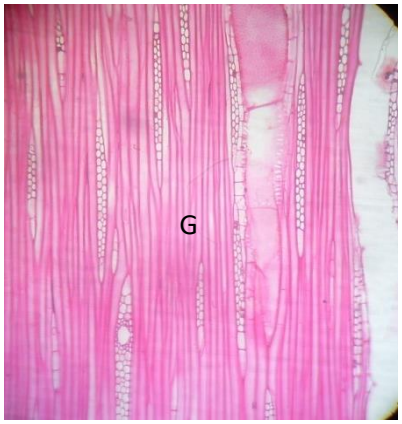
Plates A-C: Transverse section of wood species in the Castilleae tribe; A= *Antiaris toxicaria*, B = *A. africana*, C = *A. welwitschii*





Plates D&E: Transverse section of wood species in the Moreae tribe; D = *Morus mesozygia,* E = *Melicia excelsa*

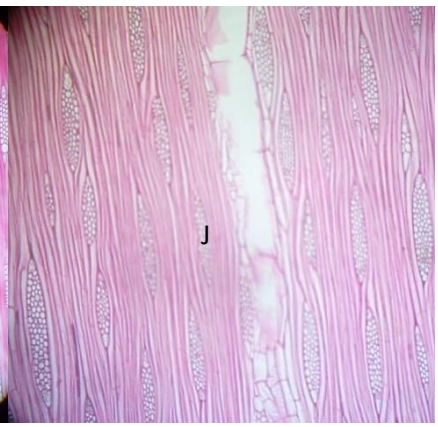




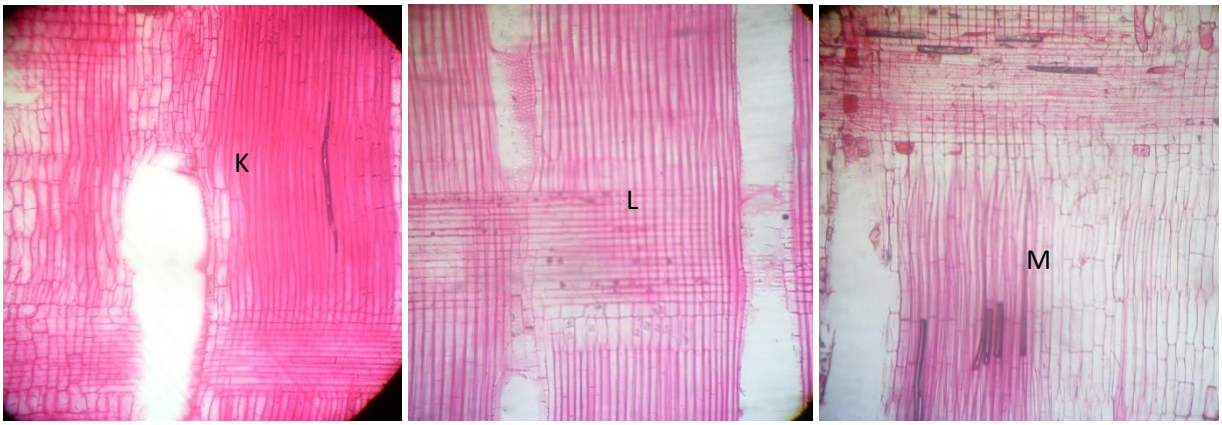


Plates F-H: Tangential longitudinal section (TLS) of wood species in the Castilleae tribe F = *Antiaris toxicaria*, G = *A. africana*, H = *A. welwitschii*

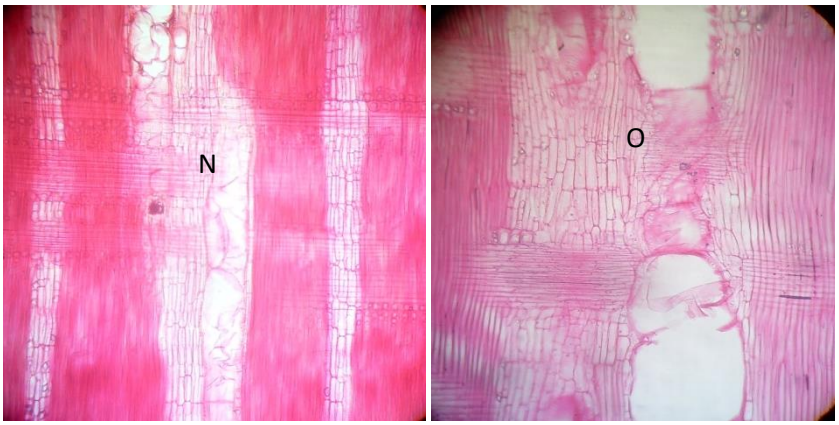




Plates I&J: Tangential longitudinal section (TLS) of wood species in the Moreae tribe: I = *Morus mesozygia,* J = *Melicia excelsa*



Plates K-M: Radial longitudinal section (RLS) of wood species in the Castilleae tribe: K= *Antiaris toxicaria*, L = *A. africana*, M = *A. welwitschii*



Plates N&O: Radial longitudinal section (RLS) of wood species in the Moreae tribe: N = ***Morus mesozygia***, O = *Melicia excelsa*

DISCUSSION

Generally, the study shows that the two tribes namely Castillae anf Moreae can be separated anatomically on the basis of mineral inclusions (prismatic crystals) which are well pronounced in Morea tribe but are not present or rare in the Castilleae tribe. Also septate fibres and sheath cells are mostly present in Castilleae tribe, the features which are not noticeably present in Moreae tribe. These features can be of diagnostic help in areas where *Antiaris toxicaria* is taken for *Melicia excelsa* as pointed out by Kaiser (1999). Within the tribe of Castilleae, rays and vessel diameter are notably wider in *Milicia excels* than those found in *Morus mesozygia* (Plates D&E), while axial parenchyma cells are conspicuously banded more in *Morus mesozygia* than in Melicia excelsa; crystals are also more abundant in the wood than in *Melicia excelsa* .Inspite of possible incidents of adulteration and mixed-up of *Morus mesozygia* and iroko (*Milicia excelsa*) logs as stated by Ofori (2007), the two species in this tribe can be separated on the bases of rays, crystals, vessels and fibers (which are thicker in *Morus mesozygia*). Of course the wood density of *Morus mesozygia* is greater than that of *Milicia excels* based on differences in fibre thickness as seen from the micrographs. The wood species within the Castilleae tribe on the other hand can be sepearated on the basis of vessels which are more numerous in Antiaris Africana thans any of other Antiaris wood species (Plates A-C). Moreover, rays are wider in *A. toxicaria* than any of the Antiaris species, while rays seem to be thinnest in *A. Africana* (Plates F-H).

CONCLUSION

Moreae and Castilleae tribes belong to the same family Moreacea, yet the anatomical features of the wood species in these two tribes are not the same. Between the two tribes there are differences and they can be separated on the account of rays, crystals and septate fibres (which are characteristic features of wood species in Castilleae tribe). Within each tribe there are anatomical features which show that wood species can still be separated whenever the need for identification arises. For instance, where *Morus mesozygia* wood is adulterated for iroko (*Milicia excelsa*), diagnostic features are differences in rays and vessels as well as banded rays.

REFERENCES

Adeniyi, I.M., Adejoba, O.R., Alao, O.J., Noah, A.S. and Salaudeen, G.T. (2013): Comparative Anatomy of Some Ficus Species." *Research in Plant Sciences* 1.2 (2013): 15-19.

Keay, R.W.J; Onochie, C.F.A.; and Stanfield (1964): Nigerian tree. Federal Departmentof Forestry Research, Ibadan.Volume II. Pp 16-187.

Keay, R. W. (1989): Trees of Nigeria. Oxford Science Publication.

Gierok Kate (2011): Ficus identification. Fotolia.com. http//www.ehow.com/m/about Hutchinson, J. and Dalziel, 1963. Flora of West Africa, Volume II

Cement, W. L. & Weiblen, G.D. 2009. Morphological evolution in the Mulberry family (Moraceae). Systematic Botany 34(3): 530-552

Ribeiro, J.E.L.S. 2007. Studies on the phylogeny, taxonomy and evolution of reproductive characters in Moraceae Gaudich. Universidade Estadual de Campinas (Ph.D thesis). 124p.

Ofori, D.A., 2007. *Milicia excelsa* (Welw.) C.C.Berg. [Internet] Record from PROTA4U. Louppe, D., Oteng Amoako, A.A. & Brink, M. (Editors). PROTA (Plant Resources of Tropical Africa / Ressources végétales de l'Afrique tropicale), Wageningen, Netherlands. <http://www.prota4u.org/search.asp>. Accessed 10 March 2016.

Toirambe Bamoninga, B. & Ouattara, B., 2008. Morus mesozygia Stapf. In: Louppe, D.,Oteng-Amoako, A.A. & Brink, M. (Editors). PROTA (Plant Resources of Tropical Africa / Ressources végétales de l'Afrique tropicale), Wageningen, Netherlands. Accessed 10 March 2016.

Ogunkunle, A.T.J. and Oladele, F.A. 2008. Structural dimensions and paper making potentials of the wood in some Nigerian speicies of *Ficus L.* (Moraceae). Advance in Natural and Applied Sciences, 2(3): 103-111.

Sytsma, K.J,; Morawetz, J.; Pires, J.C.; Nepokroeff, M.; Conti, E./ Zjhra, M.; J.C. and Chase, M.W. 2002. Urticalean Rosids: circumscription, Rosid ancestry, and phylogenetics based on rbcL, trnL-F, and ndhF sequences. *American Journal of Botany* 89(9): 1531-1546.

Ugwoke, C.E.C and UjU, G.C. 2010: Anatomical studies of selected tree species of the Moraceae family grown in Nigeria. *Journal of Prmaceutical and Allied Sciences*. Vol 7, No. 1(2010). http://dx.doi.org/10.4314/jophas.v7i1.63367.

Bosu, P.P. & Krampah, E., 2005. **Antiaris toxicaria** Lesch. In: Louppe, D., Oteng-Amoako, A.A. & Brink, M. (Editors). PROTA (Plant Resources of Tropical Africa / Ressources végétales de l'Afrique tropicale), Wageningen, Netherlands. Accessed 10 March 2016.

Wiedenhoeft, A.C., and Miller, R.B. (2002): Brief comments on the nomenclature of softwood axial resin canals and their associated cells. IAWA J. 23(3):299–303.

Public Building: Environmental Friendly Technologies for Low Cost Building

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ABSTRACT

Shelter is one of the basic necessities of life after food. The need and importance of housing to cater for the ever increasing urban population in Nigeria is causing serious challenges to urban dwellers and the government. The high cost of conventional building materials in Nigeria is making the government and the private sector to look for alternative sources of building materials locally, in order, to meet the housing needs of the ever increasing population for residential and public use at an affordable rate. This paper highlights the use of renewable resources available locally in the country for construction of public building in Nigeria. Recommendations were made on how indigenous and composite building materials can be used to meet the housing needs for public use of both rural and urban dwellers in Nigeria.

Keywords: Public building, indigenous materials, sustainability, cost effectiveness

INTRODUCTION

Massive construction of social infrastructures is one of the attributes that characterise the third world countries. The need to steadily invest and embark on infrastructures like public building amongst others cannot be over emphasised if the developing countries must transform into developed countries.

Public buildings can be defined according to Collins English Dictionary, as a building that belongs to a town or state used by the public. The Czech Republic, defines public building as buildings that are not apartments or are non-residential. According to Finland, it is defined as buildings which provide public services. France, defines it as a building that is occupied by a governmental body. Examples of public buildings are hospitals, schools, government offices, town hall, hotels, etc.

Public buildings are incredibly expensive tools that must be constantly adjusted to function efficiently. The economics of building has become as complex as its design (Wilson, in foreword to Ruegg & Marshall, 1990) . To prevent the economic recession being experienced by third world countries, Nigeria inclusive from hindering and slowing down the rate of development, consertious efforts must be made to achieve the development with cost effective and sustainable means or approach. This paper profers (as mentioned below) some practicable sustainable and cost effective applications in construction of public buildings.

Sustainable materials

These are materials and construction products which are healthy, durable, resource efficient and manufactured with regard to minimizing environmental impact and maximizing recycling (Edward, 2005). One of the most important components of a sustainable building is the material efficiency. Correct selection of building materials can be performed by taking into consideration their complete life span and by choosing products with minimal environmental impact. For instance Gonzalez and Navarro (2006) estimated that the selection of building materials with low environmental impact can reduce CO_2 emissions up to 30%. The use of renewable and recycled sources is widely encouraged as the life cycle of a building and the element can be closed.

Cost effectiveness of Public Buildings

Cost effective building is a relative concept and has more to do with budgeting and seeks to reduce construction cost through better management, appropriate use of local materials, skills and technology but without sacrificing the performance and structure life

(Tiwari *et al.*, 1999). Every owner wants a cost effective building. In many respects the interpretation is influenced by an individual's interest and objectives, and how they define "cost effective".

Is it the lowest first – cost structure that meets the program?

Is it the design with the lowest operating and maintenance costs?

Is it the building with the longest life span?

Is it the facilities in which users are most productive?

Is it the building that offers the greatest return on investment?

An economically efficient project is likely to have one or more of these attributes. However, it is impossible to summarise cost-effectiveness by a single parameter. Determining true cost-effectiveness requires a life-cycle perspective where all costs and benefits of a given project are evaluated and compared over its economic life. In economic terms, a building design is deemed to be cost-effective if it results in benefits equal to those of alternative designs and has a lower whole life cost, or total cost of ownership. Components of the whole life cost include the initial design and construction cost, on-going operations and maintenance, parts replacement, disposal cost or salvage value, and of course the useful life of the system or building.

Cost of building materials

Researchers in building sector have indicated that between 50 – 60% of the total construction input goes to the building materials. As a result, there is an urgent need to address the high cost of these products which is said to have slowed down the growth of the building and construction sector in Nigeria. Building material constitute the largest single input in housing construction. Adedeji (2010) observed that about 60% of the total housing expenditure goes for the purchase of the building materials, Arayela (2005) averted that the cost of the building materials constitute about 65% of the construction cost. Thus, adedeji (2002) rightly observed that one main barrier to the realization of effective housing in Nigeria has revealed in successive government efforts has been the cost of housing in the country. Shelter in the early periods is affordable as building materials were sourced from the immediate environment at affordable costs. But contacts with the outside world through inter regional and international training of professionals in foreign countries as occasioned by colonization brought changes to taste and hence outlook to house forms. These changes rendered the undeveloped local building materials inadequate while there was an increased demand for exotic ones. Reduction in cost is achieved through effective utilization of locally available building materials and techniques that are durable, economical, accepted by users and not requiring costly maintenance (Miles, 2000).

Environmental Friendly Building Technologies for Low Cost Housing

Successive Nigerian governments have paid lip – service to the need for alternative sources of building materials in spite of the escalating cost of the conventional or imported ones. In 1991, for instance, the housing association of Nigeria AHCN, championed the use of locally sourced building materials when in collaboration with the Akwa- Ibom state government, it built in Uyo with local materials. But that initiative was not followed up. Similarly, efforts by the Nigerian Building and Roads Research Institute NBRRI to popularise the use of local alternatives to the conventional building materials have met a brick wall, apparently because of our penchant to regard anything locally made as inferior. But with the high cost of land, funds, material and labour almost making affordable housing a mirage, the need to resort to home grown building materials has again taken the front burner.

1. Compressed Earthen Block

This is a type of manufactured construction material formed in a mechanical press that forms a compressed block out of an appropriate mix of lateric soil aggregate (Plates 1 and 2). The soil itself is generally gathered from the building site itself upon the creation of the house (65-percent of the planet's soil can be used for this process). They have been massively adopted in several countries in the world. Houses built with Red bricks are strong, durable and surely stand the test of time. Absorption capacity of the bricks keeps a house built with Red brick warm in the rainy and cold weather and cold during heat periods.





Plate 1 a: Earthen brick building b





C d



Plate 2: Completed buildings using earthen block

Compressed earth block homes are "earth-friendly" Earth block homes do not have to be dirty dwellings. They can be as clean and as modern as your architect's imagination.

What are the Benefits?

The benefits of compressed earth block homes are almost endless. Red bricks have advantages in cost, aesthetic and environmental friendliness over conventional cement bricks (Plates 3 and 4). Compressed earth blocks are nature's renewable, non-toxic material. They aren't harmful to breath in and don't endanger health like some building materials can.

Also, earth block homes are much more affordable than standard homes which take thousands of Naira. With compressed earth blocks, you can still have a nice home without having to empty out your pockets.



Plate 3

They are energy efficient. Compressed earth block homes don't require as much energy in heating and cooling saving you money. As you can see, the benefits of this eco-friendly home are convincing.



Plate 4: low cost housing unit with earthen block

The green architects of today's world have come up with many interesting sets of plans and designs for compressed earth block homes. Compressed Earth Block Homes aren't making a comeback as they never left. Our ancestors have been building them since the beginning of time because they understood the benefits. Compressed earth block homes however are making a comeback in first world nations since many green-spirited individuals who are also budget minded see the many advantages of incorporating Mother Nature into home.

2. Wooden building

A wooden building (Plate 5) is a building constructed using wood. A wooden building is relatively easy and fast to build, it requires less skill and resources than a stone house. It is suitable to use wood in building because of its thermal, acoustic, electrical mechanical, aesthetic and working properties. Unlike steel, wood does not practically expand against heat. On the contrary, by the effect of heat, it dries out and gains strength. Wood prevents echo and noise by absorbing sounds in buildings. Wooden buildings can be coated to provide protection to wood used for indoor and outdoor purposes.



Plate 5: Wooden building in FRIN

3. Timber roof trusses





Plate 6: Trusses

A timber roof truss (Plates 6-8) is a structural framework of timbers designed to bridge the space above a room and to provide support for a roof. This is another vital area of building construction that can reduce the overall cost of building some design will consume more materials that will further increase the cost. Different design at affordable cost is available in FRIN



Plate 7: Trusses design consuming more woods

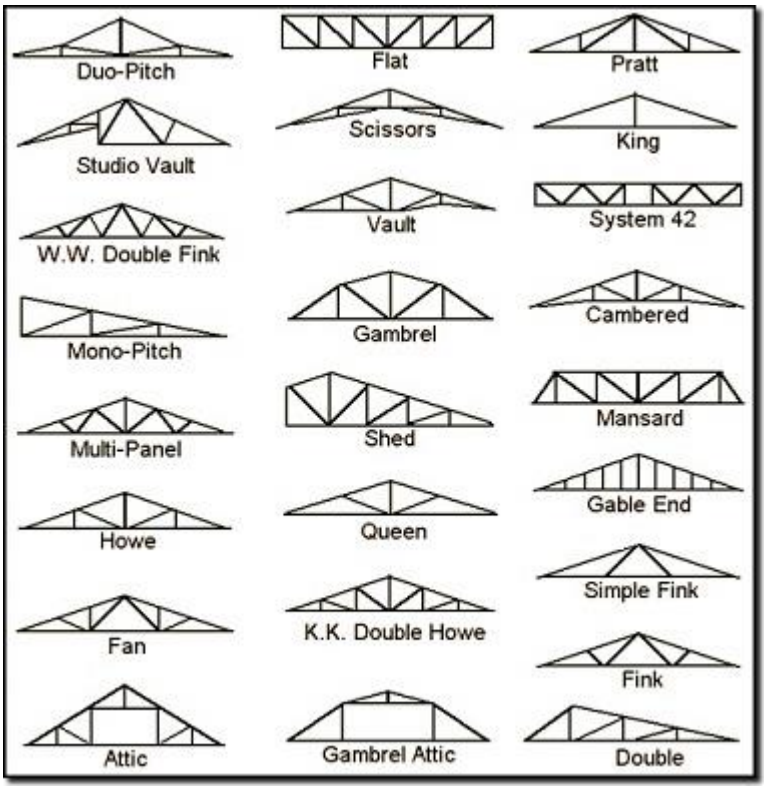


Plate 8: Different trusses design

4. Wood waste ceiling board

FRIN ceiling board products can undertake various designs and require less technical service for the production lines. The production of this building product can be semi mechanized or fully mechanized to increase the production capacity; involvement of advance technology will enhance better performance and further improved the compatibility of the fillers and the matrix used.
Importance of FRIN ceiling boards over other imported ceiling products (Plates 9 and 11) are as follows:

1. Based on the strength and stiffness, FRIN ceiling boards made at ratio 3:1 compare favourably to 6 mm thick commercial grade flat sheet asbestos-cement generally used for ceiling in Nigeria

2. In terms of water absorption, thickness swelling and linear expansion, at ratio 3:1 compare favourably to 6 mm and 4 mm thick commercial grade flat sheet asbestos-cement.

The FRIN ceiling boards has been standardized and certified using various testing mechanism to suit the building project in Nigeria. The ceiling board is an alternative to flat sheet asbestos-cement and low fibreboards in house ceiling.

Materials Used for Ceiling Boards' Production are:

1. Cement
2. Sawdust
3. Additives
4. Water



Plate 9: FRIN Ceiling Boards

Production Capacity

- ✓ The machine output: 300b/day

Size of Product

- ✓ 400 x 400 mm





Plate 10: Installed FRIN Ceiling Boards at FRIN Conference Hall and Pension Hall

Properties of the product

1. High dimensional stability
2. Stronger and stiffer in strength
3. High resistance against insect like termite
4. High resistance against fungi
5. High resistance against fire outbreak
6. Easy to handle and transport
7. Less supervision during installation
8. Aesthetic values
9. Environmentally friendly
10. Heat tolerance
11. Promote cool environment
12. Zero health risk



Plate 11: Improved face ceiling board

The properties such as improved strength, stable dimensional behaviour, high resistance to termite and fungi, high resistance to fire exposure also contributed to the advantages of the products. Ceiling boards from FRIN has being actively involved in most of the key engineering projects in the institute, colleges and individual customers. I sincerely hope this product will be of great help for primary and secondary schools rehabilitation in Osun State and other areas in the country.

5. Wooden tiles

Wood made tiles are visually pleasing, strong and durable. Unlike the conventional tiles, wooden tiles prevent slipping and are cost effective.



Plate 12: Office with Wooden tiles in FRIN

6. Bamboo building

Bamboo is one of the most cost effective construction materials available because, it is easily grown and harvested. Building with bamboo is very cheap, easy to work with due to its light weight compared to other building materials like; wood concrete or steel. Bamboo has a huge strength to weight ratio advantage, mainly because of the hollowness of its cylinder shape. Bamboo has a higher compressive strength than wood, brick or concrete and a tensile strength that rivals steel. The utilization of bamboo can be grouped into six major aspects as follows: 1. Construction, 2.furniture, 3. Paper making, 4. Textile, 5. Pharmaceutical usage and Household items.

In the constructional aspect, bamboo is used as a building material for decoration and as a structural member of a house (Plates 13-14). Bamboo has been utilized by the local populace for housing years back as poles, purlins, trusses, rafter, mats, flooring, ceiling, roof, wall, window and door frames etc. in the modern day there are prefab bamboo to finish a whole building this has been fully developed in China, India, Vietnam and Thailand. Concerted effort is being made in FRIN on bamboo building.



Plate 13: Bamboo Floor tile



Plate 14: Bamboo as poles, trusses, rafter mats, ceiling



Plate 15: Bamboo School Building in China



Plate 16: Canteen made of Bamboo in FRIN

Concrete block building

There are some concerns with concrete block construction (Plates 17 and 18) that need to be considered:
Water seepage- If you live in an area with high water table using concrete for basement can lead to seepage and water damage
Unattractive look- needs creative finishing
Cost of block- cost of building with concrete blocks can be higher than traditional frame construction.

Wood waste bock

Advantages of wood waste block

- reduction in material cost with the replacement of sawdust
- better cooling effect
- dimensionally stable
-



Plate 17: Concrete blocks

The light weight blocks produced could be used in the building industry applicable in non-load bearing situations, especially in internal partitioning and in wall panels.
This light weight blocks is useful for low cost structures as it reduces the dead weight especially in the storey structures. The addition and careful blending of sand increases the hardness and weathering, maximize the load bearing capacity and maximize of the blocks.



Plate 18: Wood waste block building

CONCLUSION

Eco-friendly building should not be a strange phenomenon considering the climate change, economic cost of building and availability of materials. It is necessary to adopt cost effective, innovative and environment-friendly housing technologies for the construction of public buildings in Nigeria considering the attending benefits. One of the materials that is readily available for construction is burnt bricks which experts described as cost effective especially in building house for the lower income and vulnerable groups. Construction using wooden materials, Bamboo and other renewable resources should further be developed to compete with the imported ones. Government should also encourage the use of these local content building materials for public buildings

REFERENCES

Adedeji, Y.M.D. (2002): Achieving affordable housing in Southwestern Nigeria through Local building material. *J. Environ. Technol.* 1 (2): 15 – 21.

Adedeji, Y.M.D. (2010): Technology and Standardized composite cement fibres for housing in Nigeria. *J. Niger. Inst. Archit.* 1:19-24.

Arayela, O. (2005): Laterite bricks: before now and hereafter. Inaugural lecture series 40 delivered at Federal University of Technology Akure, 5 – 15.

Edward, B. (2005): Rough guide to sustainability; London, RIBA Enterprises Limited. Second edition delivered at Federal University of Technology Akure, 5 – 15.

Gonzalez, M.J. and Navarro, J.G. (2006): Assessment of the decrease of CO2 emission in the construction field through the selection of materials: Practical case study of three houses of low environmental impact. Build. Environ 41: 902 – 909.

Miles, M.E. (2000): Real Estate Development, Principles and Processes, Washington D.C., Urban Land Institute.

Ruegg, R.T. and Marshall, H.E. (1990): Building Economics: Theory and Practice. VanNostrand Reinhold, New York.

Tiwari, P., Parikh, K. and Parikh, J. (1999): Structural Design Considerations in House Builder Construction Model: A Multi-Objective Optimization Technique. Journal of Infrastructure System. 5(3): pp 75-90.

Influence of Particle Gometry on Dimensional Stability of Bamboo-Reinforced Cement Composites

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ABSTRACT

A lot of materials, both organic and inorganic, have been combined with cement matrix at different ratio, all in search of materials that are most suitable for a particular end use. This study determined the dimensional stability of bamboo-reinforced cement composites. Cement bonded composites (35mm-cube) were made from particles derived from bamboo (Bambusa vulgaris). The proportion of cement, sand, stone-dust and bamboo content was done by weight in a nominal mix of 1:2:4. Bamboo particles and chemical accelerator's substitutions were based on sand and cement proportions respectively. Mean Water Absorption after 2h of immersion in cold water ranged between 11.6 to 24.0% (at 0% $CaCl_2$) and 10.6 to 18.2% (at 3%$CaCl_2$). After 24h the range was between 13.1 to 24.4 % (at 0%$CaCl_2$) and 11.2 to 20.0 % (at 3%$CaCl_2$). The range of values of mean TS after 2h of immersions was 0.1 to 0.34% and 0.09 to 0.36% following 2h soaking at 0% and 3%$CaCl_2$ respectively. After 24h of immersion the range was 0.11 to 0.35% at 0%$CaCl_2$ and 0.10 to 0.37 at 3% $CaCl_2$. Based on the findings, it was therefore concluded that composites produced with 850µm particle size at 10% particle content and 3%$CaCl_2$ had less water absorption and thickness swelling potentials.

Keywords: Bamboo particles, dimensional stability, chemical accelerator, thickness swelling and water absorption

INTRODUCTION

Fibre Reinforced Cementitious Composites (FRCC) presents new possibilities in the design of civil structures since they exhibit superior tensile strength, ductility and crack resistance compared to ordinary concrete. These render them well suited for use in structures exposed to cyclical and extreme live loads (Tsung – Chin Hou, et al; 2005). They are extremely weather and fire resistant, environmentally friendly, possess good thermal insulation and have enhanced strength properties with age compared with concrete. These excellent properties coupled with high mechanical durability have rendered them suitable for use in a variety of realistic structural applications such as highway bridges slabs (Li V., *et al*; 2002) and bridge piers (Billington, *et al;* 2002).

A lot of materials, both organic and inorganic, have been combined with cement matrix at different ratio, all in search of materials that are most suitable for a particular end use. In lignocellulosic- cement composites, furnishes from wood, agricultural crops, like jute or kenaf, agricultural wastes such as bagasse, corn stalks, and other plant substances, e.g. grass have been used and are still under further investigation (Badejo, 1988, Badejo, 1989).

Wood can serve as a low-cost filler and/ or reinforcing material which greatly improve the stiffness, fracture toughness, strength – to-weight ratio, creep deflection, and thermal and acoustic resistance of cement when incorporated into a composite bonded with cement (Goodell *et al;* 1997). However, in view of the increasing demand for wood and wood products, and the extensive period wood requires to regenerates, there is the need to evaluate the suitability of other lignocellulosics. Bamboo is an excellent substitute as a cheap, fast-growing minor forest product which is widely available (Sattar, 1995). It possesses excellent strength properties which may be carried over into the composites when its particles are mixed with cement. Therefore, in order to fully understand the various potential application areas, there is the need to study the dimensional stability of the resulting composites. This is in effect dependent on a number of factors including the particle size and content, mixing ratio, additive accelerators, and treatment methods adopted.

MATERIALS AND METHODS

The culms of *Bambusa vulgaris* used in this work were collected within the premises of The University of Ibadan, Nigeria and their physical conditions were inspected to ensure that only matured and healthy culms were harvested. The green bamboo culms were cut into pieces of average length of 4ft and then air-dried to ensure breakdown of sugar and other extractives that could inhibit bonding with cement. The dried culms were then sliced and chipped with cutlass into average dimension of 1" x 3" to ensure easy milling. The

chips were milled into flakes with hammer mill and sieved into fines and particle sizes of 850µm and 1.18mm. A mixing ratio of 1: 2: 4 was employed in the production of the composites. The proportion of cement, sand, stone dust and bamboo fibres were done by weight for the two particle sizes, i.e. 850µm and 1.18mm. 10% and 20% untreated fibre substitution of sand proportion was done at two levels of additive concentration (0% and 3%). Cement, sand and stone dust were first mixed in the dry state properly to ensure uniformity. The fibres were then added and thoroughly mixed. The aggregates were mixed manually since only a small quantity was required for each treatment. Water was gradually introduced and mixed concurrently using hand with gloves until sufficient plasticity and good workability was attained. A flat tray overlaid with a polythene interface was placed on a flat table and a wooden mould positioned on it. A steel spoon was used to spread and level up the mortar evenly to the mould thickness of 35mm. It was then compacted with tamping bar to eliminate voids and honeycombs. The mould was then detached and the resulting cubes left in the open air to dry. After the initial setting, which took place in a dry cool place for a period of twenty-four hours, the cubes were then subjected to wetting for seven days to prepare them for twenty one days curing. Curing for this project work took a total of twenty eight days. This is to ensure complete hydration of cement to enable the composite samples attain their full satisfactory strength.
The initial thickness and weight of the samples were taken and recorded before immersion in cold water. At the end of 2hrs, the samples were removed and wiped dry with a clean handkerchief to avoid dripping. Then the final thickness and weight of the samples were taken and recorded. These were repeated following 24hrs of immersion in cold water, i.e. 22hrs after the first test. In order to find the relationship between particle size, particle content and chemical accelerators on the thickness and water absorption potentials of the composites, statistical analyses were done using Analysis of Variance and Duncan Multiple Range Test.

RESULTS AND DISCUSSION

Water Absorption

The mean water absorption after 2hrs of immersion in cold water ranged from 11.6 to 24% for the untreated particles and between 10.6 – 18.2%for those treated with 3% $CaCl_2$ (Tables 1and 2). However, after 24hr of immersion, WA ranged from 13.1 – 24.4% and 11.2 – 20.9% for untreated particles and those treated with 3% $CaCl_2$, respectively. These values are relatively low compared to some other lignocellulosics, e.g. bagasse (41.52%), coconut husk (30.55%) (Oyagade, 2000)

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Table 1: Mean Water Absorption, WA%, of the BCCS after 2h of immersion in cold water

Bamboo Content (%)	Water Absorption, WA%			
	Untreated		Treated with 3% $CaCl_2$	
	850µm	1.18mm	850µm	1.18mm
10	13.9	11.6	11.7	10.6
20	19.0	24.0	18.2	14.7

Table 2: Mean Water Absorption, WA%, of the BCCS after 24h of immersion in cold water

Bamboo Content (%)	Water Absorption, WA%			
	Untreated		Treated with 3% $CaCl_2$	
	850µm	1.18mm	850µm	1.18mm
10	14.9	13.1	13.3	11.2
20	21.2	24.4	20.9	16.5

Effects of Particle size on WA

The bccs produced with 850µm particles generally absorbed less water after 2hrs and 24hrs than those produced with 1.18mm particle size (Figure 1).. This was in line with the findings of Olorunnisola (2005), that the smaller the particle size, used for board production, the greater the board density, and the less the water absorption potentials.

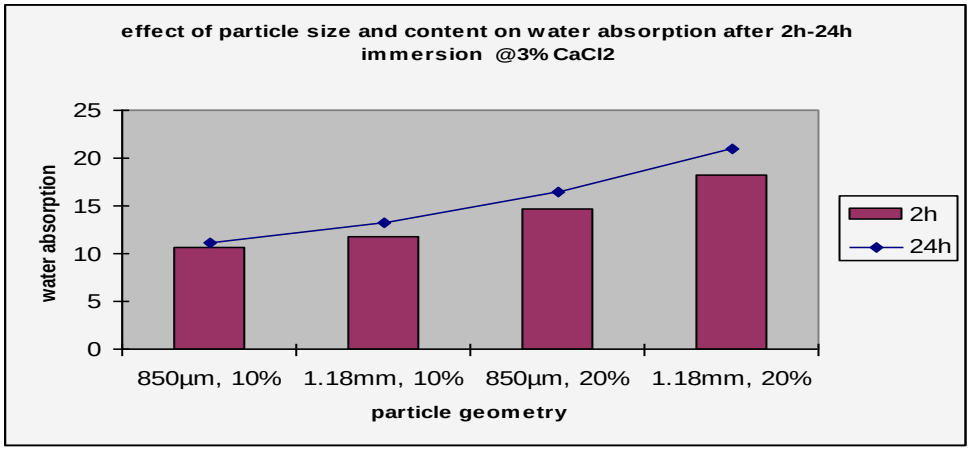


Fig 1: Effect of particle size and content on water absorption after 2h-24h immersion @3% $CaCl_2$

Effects of particle content on WA

A higher value of WA was observed with 20% bamboo content. Composites made with 10% bamboo content absorbed less water at the end of 2hrs and 24hrs for both particle sizes (Table 3 and Figure 2). This may be linked to the fact that composites density decreases as the fibre content increases because lignocellulosics are lightweight. (Olorunnisola, 2005)

Table 3: Duncan Multiple Comparison for WA of the composites after 2h and 24h of immersion in cold water

Factors	Variables	WA%	
		2h	24h
Particle content	10%	11.93[b]	13.09[a]
	20%	18.96[a]	20.94[b]
Particle size	850µm	15.19[a]	16.30[b]
	1.18mm	15.70[a]	17.54[a]
Chemical conc.	0%	17.13[a]	18.39[a]
	3%	13.76[b]	15.44[a]

-Means with the same letters are not significantly different

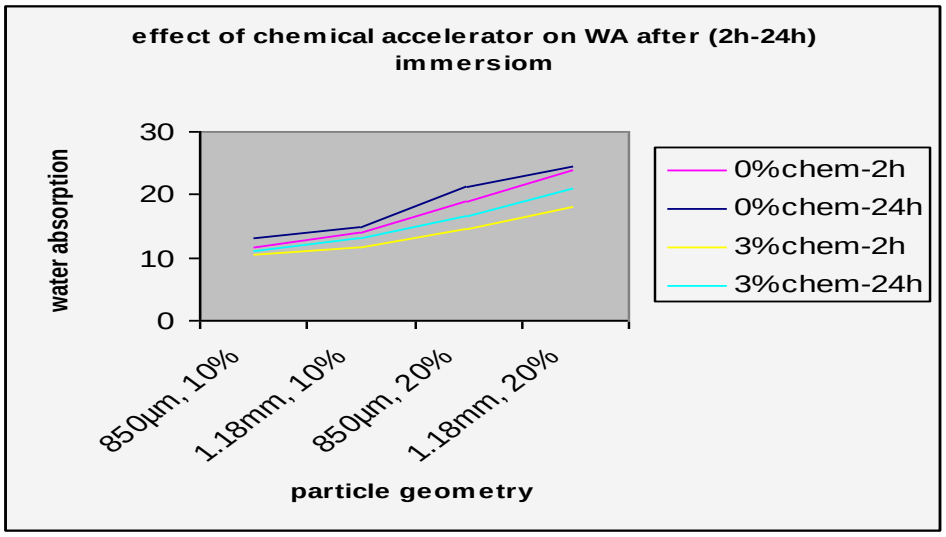


Fig 2: Effect of chemical accelerator on WA after (2h-24h) immersion

Thickness Swelling

The mean thickness swelling, TS for the composites after 2h and 24hr immersion are as shown in Tables 3 and 4. The range of values of TS was 0.10 – 0.34% and 0.11 – 0.35% for untreated particles following 2hr and 24hrs of immersion respectively. Composites made with 3% $CaCl_2$ had a range of 0.09 – 0.36% and 0.10 -0.37% following 2hr and 24hr of immersion, respectively (Tables 4 and 5).

Table 4: Mean Thickness Swelling TS% of the BCCS after 2h of immersion

Bamboo Content (%)	Thickness Swelling TS%			
	Untreated		Treated with 3% $CaCl_2$	
	850µm	1.18mm	850µm	1.18mm
10	0.10	0.21	0.09	0.17
20	0.16	0.34	0.15	0.36

Table 5: Mean Thickness Swelling TS% of the BCCS after 24h of immersion

Bamboo Content (%)	Thickness Swelling TS%			
	Untreated		Treated with 3% $CaCl_2$	
	850µm	1.18mm	850µm	1.18mm
10	0.11	0.21	0.10	0.18
20	0.17	0.35	0.16	0.37

These values are relatively low in comparison with the TS of some other lignocellulosics e.g. bagasse (3.98%) and Gmelina sawdust (4.45%) (Oyagade, 2000)

Effects of Particle size and content on Thickness Swelling

Higher TS values were observed with 1.18mm particles at 10%following 2h and 24h immersion in cold water. This was about 110% and 90% than bccs made with 850µm particles at 10% following 2h and 24h of immersion respectively. The same was observed at 20% particle content, with 1.18mm being between 112% and 88% higher than 850µm particle size at the end of 2h and 24h immersion, respectively. Composites made at 20% content had higher values of TS for both particle sizes. This was about 50% and 54% at the end of 2h and 24h immersion, respectively (Figure 3).

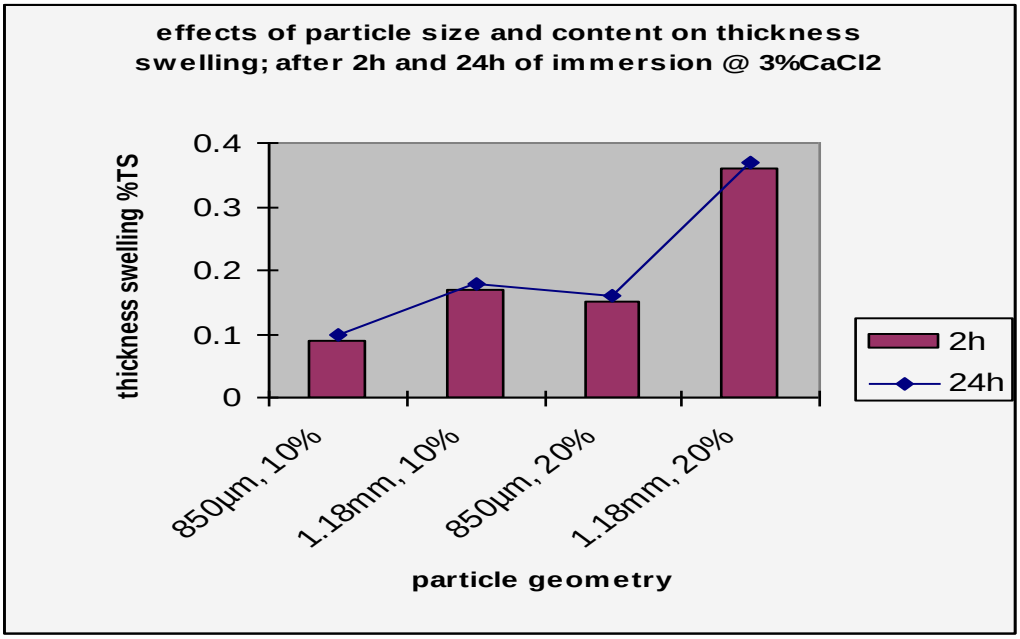


Fig 3: Effect of particle size and content on thickness swelling TS after (2h-24h) immersion @3% $CaCl_2$

Effects of Chemical Accelerator on TS

The addition of 3% $CaCl_2$ generally reduced the TS values of the bccs drastically. The TS of those made with 850µm at 10% particle content reduced by 10% and 9% at the end of 2h and 24h respectively. A reduction of 6% and 5.8% was also observed with those made at 20% particle content. Similarly, BBCs made with 1.18mm particle size at 10% particle content had a reduction in TS values by 19% and 14%with the addition of 3%$CaCl_2$ at the end of 2h and 24h respectively. However, this had an adverse effect on the TS of the bccs at 20% particle content (Table 6 and Figure 4).

Table 6: Duncan Multiple Comparison for TS of the composites after 2h and 24h of immersion in cold water

Factors	Variables	TS%	
		2h	24h
Particle content	10%	0.14^{b}	0.15^{b}
	20%	0.27^{a}	0.26^{a}
Particle size	850µm	0.12^{b}	0.13^{b}
	1.18mm	0.27^{a}	0.27^{a}
Chemical conc.	0%	0.20^{a}	0.21^{a}
	3%	0.19^{a}	0.20^{a}

-Means with the same letters are not significantly different

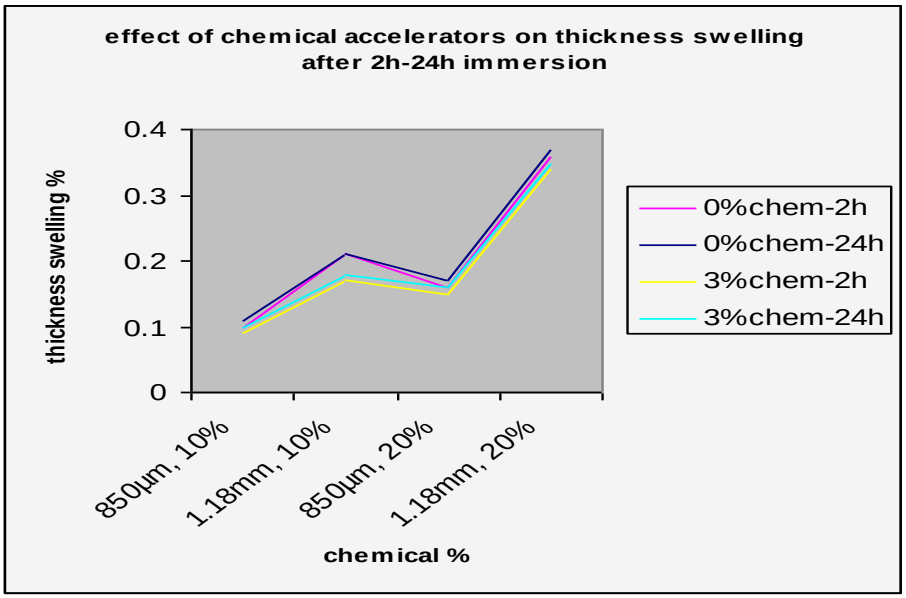


Fig 4: Effect of chemical accelerator on thickness swelling TS after (2h-24h) immersion

CONCLUSION

Based on the data collected and their statistical analyses, the following conclusions are drawn:

1. Bamboo-reinforced composites made at 3% additive concentration, 10% particle content and 850µm particle size have less water absorption (WA), and thickness swelling (TS) potentials.
2. Direct relationships existed between particle size, particle contents and dimensional stability.

REFERENCES

Badejo, S.O. (1988): "Effect of flake geometry on properties of cement-bonded particle boards from mixed tropical hardwoods". Wood Science and Technology 22(4), 357-370

Badejo, S.O. (1989): "Influences of pre-treatment temperature and additive concentration on the properties of cement-bonded particleboard from plantation grown tropical hardwoods". Tropical Science 29(4), 285-296.

Goodell, B., Daniel, G., Liu, J., Mott, L. and Frank, R. (1997): "Decay resistance and microscopic analysis of wood-cement composites". Forest Products Journal 47(11/12), 75-80.

Li, V., Fischer, G., Kim, Y., Lepech, M., Qian, S., Weemanm, M. and Wang, S., (2003): "Durable link slabs for jointless Bridge Decks based on Strain Hardening Cementitious Composites". Technical Report RC-1438, Michigan Department of Transportation, November, 2003

Olorunnisola, A.O. (2005): "Dimensional Stability of cement-bonded composite boards made from rattan cane particles". *Journal of Bamboo and Rattan*, Vol. 4, N0. 2. pp. 73- 182.

Oyagade, A.O. (2000): "Thickness Swelling components and water absorption of cement particleboards made from Gmelina wood, bagasse and coconut husks". *The Nigerian Journal of Forestry*. 30(1),10-14

Sattar, M.A. (1995): "Traditional Bamboo Housing in Asia: Present Status and Future Prospects",In: Bamboo, People and The Environment. Proceedings of the Vth nternational Bamboo Workshop and the IV International Bamboo Congress, Ubud, Bali, Indonesia 19-22 June 1995

Tsung-Chin Hou, Jerome Peter Lynch, (2005): "Monitoring Strain in ECC using wireless sensors". Proceedings of the International Conference on Fracture (ICFXI), Turin, Italy, March 20-25, 2005.

Axial and Radial Variation in Selected Mechanical Properties of *Terminalia mantaly (*H. PERRIER)

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ABSTRACT

There is a need to provide alternative species by investigating the technical qualities of species that are hitherto not harvested. Four trees of T. mantaly with an average height of 15m were selected and felled. Bolts of 50cm long were cut from the felled trees at the base, diameter at breast height (Dbh), middle and top (sampling height). Samples were collected from bark-to-bark (peripheral1, inner1, inner2 and peripheral2) along the radial position for base, Dbh, middle and top. Selected mechanical properties, namely, modulus of rupture (MOR), modulus of elasticity (MOE) and impact bending (IB) were investigated. Data were analysed using analysis of variance. The mean value for MOR is 59.92±13.04 N/mm^2 ranging from 50.18 N/mm^2 to 67.97 N/mm^2 along the tree height and radially, ranges from 48.10 N/mm^2 to 71.66 N/mm^2. The mean value for MOE is 5096.35±951.68 N/mm^2 ranging from 4093.96 N/mm^2 to 6032.46 N/mm^2 from the base to the top along the axial direction and radially, ranges from 4444.14 N/mm^2 to 5787.96 N/mm^2 from bark to bark. The mean value for IMB is 0.41±0.10 m ranging from 0.32 m to 0.51 m from base to the top and radially, ranges between 0.34 m to 0.48 m. For all properties investigated, no significant variation was found from the inner to the outer wood. This study has therefore provided basic information on some mechanical properties of Terminalia mantaly wood which will serve as baseline information for its efficient and proper utilization.

Keywords: Modulus of rupture, modulus of elasticity, *Terminalia mantaly*, impact bending, axial and radial variations.

INTRODUCTION

Nigeria is blessed with a large expanse of land area of about 983,213 km^2 with a forest area of about 345,000 km^2, which is 35% of the total land area (Adedokun *et al*., 2005). The rate at which the forest is being depleted today due to population growth, indiscriminate logging, removal for constructional purposes and farming is alarming (Adekunle et al, 2002). Today the 10% of land area under reserve (9.5 million ha), falls short of the 25% originally proposed by FAO (1989) policy. According to Okojie (1994), about 4,600 plant species have been recorded in Nigeria. Akachuku (1997) noted that over 560 tree species in Nigerian forest can attain a height of at least 12m and a girth of 60cm when matured. According to Panshin and deZeeuw (1980), tree size and good quality are considered as the major factors determining the suitability of wood for various industrial end uses. *Terminalia mantaly* (Combretaceae), grows 10-20 m with an erect stem and neat, conspicuously layered branches. Bark pale grey, smooth and rather mottled. Leaves smooth, bright green when young, in terminal rosettes of 4-9 unequal leaves on short, thickened stems; length up to 7cm, apex broadly rounded, base very tapered, margin wavy. Flowers small, greenish, in erect spikes to 5cm long. Fruit small oval, seeds, about 1.5cm long with no obvious wings. The provision of database on the characteristics of the *T. mantaly* species is needed and would go a long way in promoting the utilisation potential.

MATERIALS AND METHODS

Four trees of *T. mantaly* with an average height of 15m were selected and felled from the Department of Forest Resources Management of the University of Ibadan, Oyo State, Nigeria located on latitude 7.4417^{0}N and longitude 3.9000^{0}E. Bolts of 50cm long were cut from the felled trees at the base, diameter at breast height (Dbh), middle and top (sampling height). The bolts were then taken to the Department of Forest Resources Management Wood Workshop, University of Ibadan for further conversion to test samples according to BS 373 (BSI, 1989). Samples were collected from bark-to-bark (peripheral1, inner1, inner2 and peripheral2) along the radial position for base, Dbh, middle and top.

Testing of the *Terminalia mantaly* Samples

Samples were cut to 20mm x 20mm x 300mm for Modulus of Rupture (MOR), Modulus of Elasticity (MOE) and Impact Bending (IMB) test in accordance with British Standard specification BS 373 (BSI, 1989). Each treatment combination was replicated four times and 64 samples were obtained for each of the parameters tested. Analysis of variance in 4 x 4 factorial experiments in a completely randomized design (CRD) was carried out to determine if the sampling height and radial position had significant effects on the strength properties of the *T. mantaly*.

Determination of Modulus of rupture (MOR)

Samples of 20mm x 20mm x 300mm dimension according to British Standard specification BS 373 (BSI, 1989) were tested with a Hounsfield Tensiometer. The load was applied at the rate of 0.1mm/sec. The bending strength of wood usually expressed as MOR, which is the equivalent fibre stress in the extreme fibres of the specimen at the point of failure was then calculated using the formula;

$$MOR = \frac{3PL}{2bd^2} \quad \text{.....Eqn. 1}$$

Where:

MOR = Modulus of Rupture (N/mm^2)
P = The failing load (N)
L = The specimen span between centres of support (mm)
b = Width of the specimen (mm)
d = Thickness of the specimen (mm)

Determination of Modulus of elasticity (MOE)

The modulus of elasticity was calculated from the values obtained from the load-deflection graph during the test for Modulus of Rupture (MOR). The formula employed is given as;

$$MOE = \frac{PL^3}{4bd^2\Delta} \quad \text{.....Eqn. 2}$$

Where:

MOE = Modulus of Elasticity (N/mm^2)
P = The failing load (N)
L = The specimen span between centers of support (mm)
b = Width of the specimen (mm)
d = Thickness of the specimen (mm)
Δ = Slope from the graph.

Determination of Impact Bending (IMB)

The impact bending test was carried out using Hatt-Turner Impact Test Machine following British Standard specification BS 373 (BSI, 1989). In this method, test specimen of 20mm x 20mm x 300mm were supported over a span of 240mm on a support radius 15mm, spring restricted yokes are fitted in order to arrest re-bounce.
This was then subjected to a repeated blow from a weight 1.5kg at increasing height initially from 50.8mm and then every 25.4mm until complete failure occurred at which point the height was recorded in meter as the height of maximum hammer drop.
Impact bending was calculated using the formula;

$$IMB = \frac{MPL}{db^2} \quad \text{.....Eqn. 3}$$

Where**:**

IMB = Impact Bending (KJ/m^2)
MPL = Bending moment at proportional limit (KJ/mm)
b = Width of the beam (mm)

		Radial Position (Across the Bole)				
Strength Properties	**Sampling Height**	**Peripheral1**	**Inner1**	**Inner2**	**Peripheral2**	**Mean**
MOR (N/mm^2)	**Base**	78.83	57.94	56.81	78.30	67.97±11.00[a]
	Dbh	73.69	54.56	52.43	71.44	63.03±10.00[b]
	Middle	69.19	48.14	47.98	68.69	58.50±10.88[c]
	Top	64.94	38.81	35.19	61.79	50.18±13.85[d]
Mean		71.66±5.53[a]	49.86±7.63[c]	48.10±8.53[d]	70.06±6.24[b]	**59.92±13.04**
	Base	6751.78	5421.14	5414.63	6542.28	6032.46±656.83[a]

MOE (N/mm^2)	**Dbh**	5921.54	5022.47	4976.15	5790.12	5427.57±453.27[b]
	Middle	5633.85	4330.49	4013.09	5348.18	4831.40±710.86[c]
	Top	4844.65	3527.79	3372.70	4630.69	4093.96±680.69[d]
Mean		5787.96± 713.78[a]	4575.47± 751.72[c]	4444.14± 840.15[d]	5577.82± 723.12[b]	**5096.35±951.68**
	Base	0.57	0.49	0.45	0.54	0.51±0.05[a]
IMB	**Dbh**	0.51	0.38	0.36	0.50	0.44±0.07[b]
(m)	**Middle**	0.45	0.31	0.30	0.43	0.37±0.07[c]
	Top	0.39	0.25	0.25	0.39	0.32±0.07[d]
Mean		0.48±0.07[a]	0.36±0.09[c]	0.34±0.08[d]	0.47±0.06[b]	**0.41±0.10**

d = Thickness of the beam (mm)

RESULTS AND DISCUSSION

Table 1: Summary of Mean values of selected Strength properties of *Terminalia mantaly* Samples
* Means of four replicate samples. Values are significantly different from one another at $\alpha = 0.05$ using Duncan multiple range test.

Modulus of Rupture (MOR)

The mean value for MOR is 59.92±13.04 N/mm^2 ranging from 50.18 N/mm^2 to 67.97 N/mm^2 along the tree height (Table 1). Radially, MOR decreases from the bark (peripheral) to the inner part of the wood of *T. mantaly* and increases towards the bark again (Fig. 1) ranging from 48.10 N/mm^2 to 71.66 N/mm^2. It was also observed that MOR decreased from base to top of *T. mantaly* wood (Fig. 1). The highest MOR values were obtained at the base. These finding agrees with Ogunsanwo, (2000) for *Triplochiton scleroxylon* and also with Adejoba and Onilude, (2009) for *Ficus mucoso*. Ogunsanwo (2000) and Haygreen and Bowyer (1996) emphasized that, variations in some morphological parameters such as fibre length, wall thickness and fibre diameter causes increase of MOR from core wood to outer wood, which also increased in the same pattern. The trend of variations in MOR from base to top and inner wood to outer wood might be due to decrease and increase in fibre length respectively (Rulliaty and America, 1995). Biblis, (1994) states that MOR decreases as the position of sampling moves up the tree.

The result of analysis of variance for MOR presented in Table 2 showed that the differences in sampling height, radial position and their levels of interaction had a significant effect ($P<0.05$) on MOR. The follow up test as presented in Table 1 shows that samples from the base and at the peripheral position were significantly different from samples obtained at the middle and the top, thus indicating that samples from the base and peripheral are most preferred.

Table 2: Result of the Analysis of Variance for Selected Strength Properties of *T. mantaly* Samples

		F-cal					
Source of variation	**Df**	**MOR Sig.**	**MOR**	**MOE Sig.**	**MOE**	**IMB Sig.**	**IMB**
Sampling Height	3	0.000	345.24*****	0.000	597.52*****	0.000	354.43*****
Radial Position	3	0.000	970.27*****	0.000	407.86*****	0.000	265.89*****
Sampling Height * Radial Position	9	0.000	5.94*****	0.001	4.17*****	0.001	3.85*****
Error	48						
Total	63						

* Significant at P= 0.05

Modulus of Elasticity (MOE)

The mean MOE presented in Table 1 is 5096.35±951.68 N/mm^2 ranging from 4093.96 N/mm^2 to 6032.46 N/mm^2 from the base to the top along the axial direction. Across the bole, the MOE value ranges from 4444.14 N/mm^2 to 5787.96 N/mm^2 from bark to bark (Table 1). MOE varied consistently along the bole. It was observed that, samples collected at the base produced the highest MOE, followed by the samples at the Dbh and then the samples from the middle while, the samples collected at the top had the lowest MOE (Fig. 2). It was also observed that MOE decreases from bark (peripheral) to the inner core and increases towards the bark again (Fig. 2). These findings agree with the work of Fuwape and Fabiyi, (2003) on *Nauclea diderrichii* and Adedipe, (2004) on *Gmelina arborea*. MOE varies systematically with height of tree and most variation in MOE is due to variation in micro fibril and specific gravity (Megraw, 2002). Asafu-Adjaye, *et al.,* (2013) also stated that there is variation along and across the bole of *B. aethiopum* from Ghana. The result of the analysis of variance for MOE (Table 2) shows that the differences in sampling height, radial position and their interaction had a

significant effect on MOE at 5% level of significant. The follow up test (table 1) further revealed that samples from the base and at the peripheral position were better than other samples from the middle and top as well as from the inner position of *T. mantaly*.

Impact Bending Strength (IMB)

From Table 1, the mean value for IMB is 0.41±0.10 m ranged from 0.32 m to 0.51 m from base to the top. Across the bole, it ranges between 0.34 m to 0.48 m as presented in Table 1. It was observed that IMB decreased from base to top and also from the bark (peripheral) to the innermost part of the wood of *T. mantaly* and increases towards the bark again (Fig. 3). It was also observed that the samples that have more ability to withstand shock loading were obtained at the base compared to those obtained at the Dbh, middle and top. The findings of this work are similar to that of Adejoba and Onilude (2009) and Adedipe (2004) on *Ficus mucoso* and *Gmelina arborea* respectively. They stated that IMB decreases from base to top. This variation pattern in IMB may be attributed to the fact that wood is a natural material and the tree is subject to many constantly changing influences, hence wood properties vary considerably (Green *et al*, 1999). The Analysis of variance result for IMB showed that the differences in sampling height, radial position and their levels of interaction had a significant effect on IMB of the *T. mantaly* samples at P<0.05 (Table 2). The follow up test further revealed that sampling height and radial position were different from one another (Table 1) with the samples from the base and the peripheral having a better IBM.

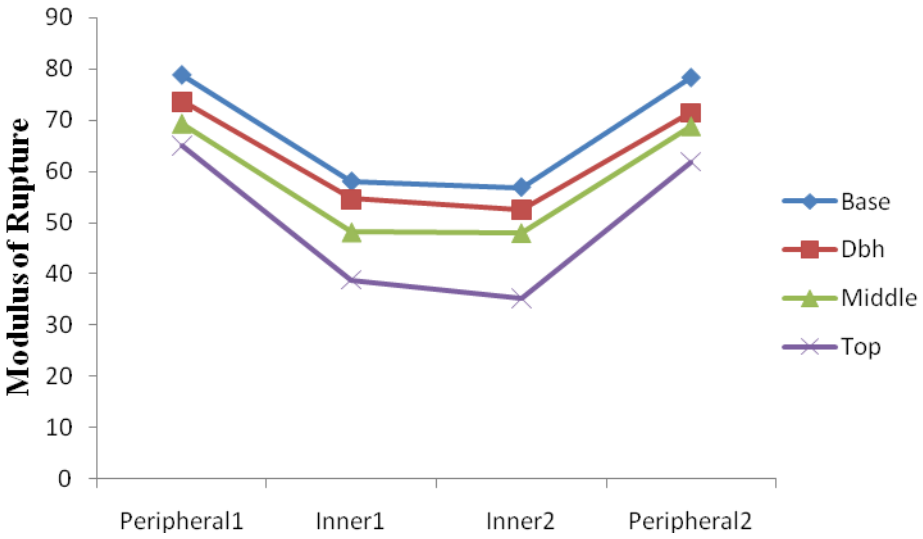


Figure 1: Effect of sampling height and radial position on Modulus of Rupture (N/mm^2) Conducted on *T. mantaly*

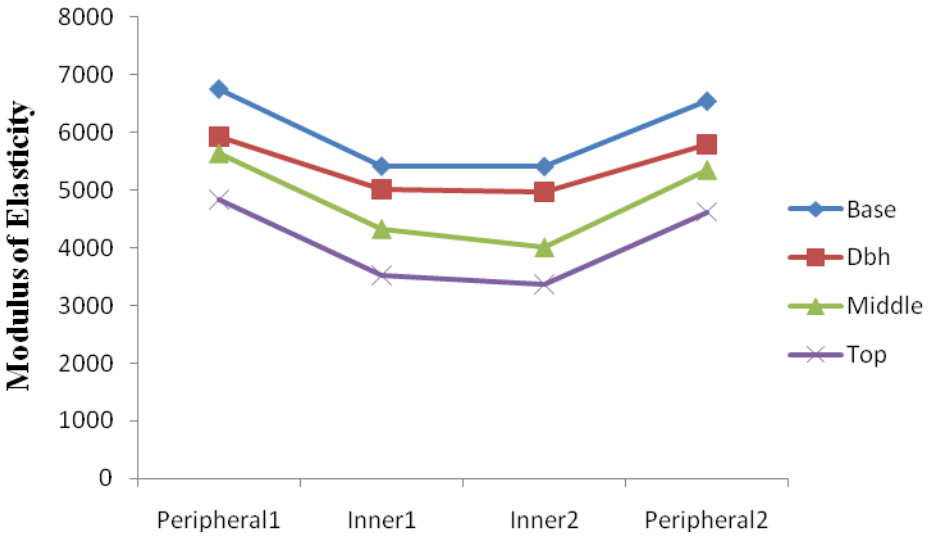


Figure 2: Effect of sampling height and radial position on Modulus of Elasticity

(N/mm^2) Conducted on *T. mantaly*

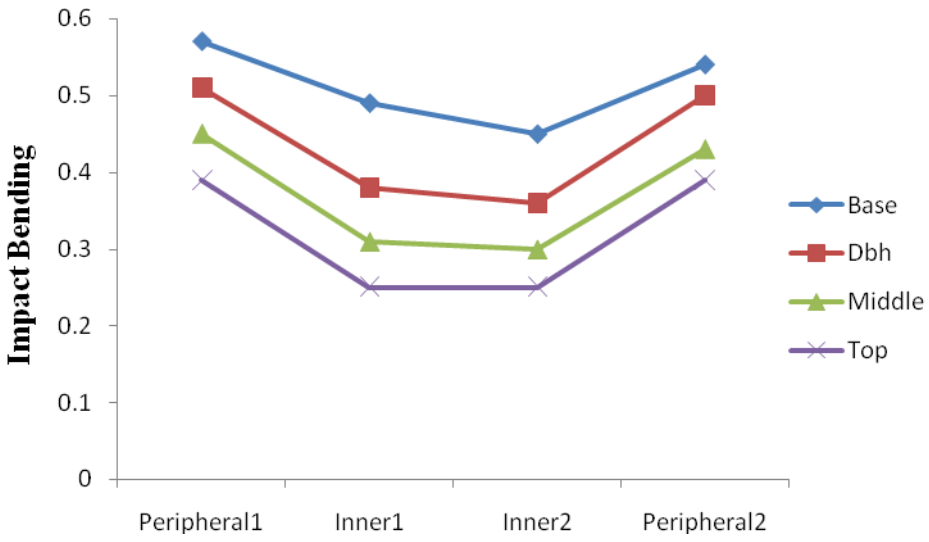


Figure 3: Effect of sampling height and radial position on Impact Bending (m) Conducted on *T. mantaly*

CONCLUSION

The study showed that strength properties were influenced by sampling height and radial position. The study revealed that strength properties decrease radially across the bole of *T. mantaly* from the bark (peripheral) to the inner part and increases towards the bark again (bark-to-bark). The study further revealed that along the axial direction from base to top, modulus of rupture, modulus of elasticity and impact bending strength decreases.

The study also showed that the samples collected from the base were the strongest in terms of strength, as well as samples obtained at the peripheral from each of the sampling heights (base, Dbh, middle and top) produced the strongest and better strength compared to samples from the innermost position.

This study has therefore, provided basic information on some mechanical properties of *Terminalia mantaly* wood which will serve as baseline information for its efficient and proper utilization.

REFERENCES

Adedipe, O. E. (2004): Machining and Mechanical properties of plantation grown *Gmelina aborea* wood. Thesis submitted for the award of Master of Agricultural Technology. Department of Wood Products Technology, Federal University Technology, Akure. Pp 81.

Adedokun, O.A., Oladoja, M.a. and Adisa, B. O. 2005. Forestry extension services in Nigeria: prospects and challenges: In Popoola, L. P. Mfon and P.I. Oni (Eds). Proceedings of the 30th Annual Conference of Forestry Association of Nigeria. 136-144.

Adekunle, V.A., Akande S.O. and Fuwape J.A. (2002). Impacts of over exploitation on biodiversity yield and sustainable use of tropical rainforest ecosystem: A case study of Omo Forest Reserve, South West Nigeria. Proceedings of the 28th annual conf: Forestry Association of Nigeria: 252-263.

Adejoba, O. R. and Onilude, M.A. (2009): Axial and Radial Variation in Mechanical properties of *Ficus mucoso*. *Journal of Agricultural Technology and Rural Development.* Vol. 1 No 1. Pp 32-38.

Akachuku, C. O. 1997. Status of Forest food plant species and environmental management in South Western Nigeria. (Eds. *Proceedings of Forestry Association of Nigeria Annual Conference*. 21-29.

Asafu-Adjaye, Osei Asibe, Frimpong, Mensah Kwasi and Darkwa, Nicholas Albert (2013): Assessment of the effects of density on the mechanical properties variations of *Borassus aethiopum.* Scholars Research Library Archives of Applied Science Research, 2013, 5 (6): 6-19. *Available online a*t *www.scholarsresearchlibrary.com*

British Standard Institution, (1989): Methods of Testing Small Clear Specimen of Timbers. British Standard Institution, UK., pp: 137.

Fuwape, J.A. and Fabiyi, J.S. (2003): Variation in Strength Properties of Plantation Grown *Nauclea diderichii* Wood. *Journal of Tropical Forest Products* 9 (1&2): 45-53.

FAO. 1989. Forestry Series No. 24; Statistic Series No. 97; 336pp.

Green, D. W., Winandy, J. E. and Krestchmann, D. E. (1999): Mechanical Properties of wood.Wood handbook. Wood as an engineering material. Madison, WI USDA Forest service. Forest Products laboratory, 1999, general technical report FPL; GTR-113: pp 1-45.

Haygreen J.G and Bowyer J.L. (1996): Forest Products and Wood Science, 3rd edn. AMES, Iowa State University Press, pp 232.

Ogunsanwo, O.Y. (2000): Characterization of Wood Properties of Plantation grown Obeche (*Triplochiton sceleroxylon.* K. Schum) in Omo Forest Reserve. Ogun State, Nigeria, Ph.D Thesis in the department of forest Resources Management. Univ. of Ibadan pp 253.

Okojie, J.A. and Akande, J.A. (1995). Environmental Sustainable Wood Industry Development. Nigerian Journal of Forestry Vol.25 (No. 1&2) 101-103.

Panshin, A. J. and Dezeeuw, C. 1980. Textbook of Wood Technology. Vol. 1 Fourth Edition inc. Graw-Hill Boo Company. 704pp

Rulliaty, S. and America, W.A. (1995): Natural variation in wood quality indicators of Indonesia big leaf Mahogany (*Swietenia macrophylla*) King. XX IUFRO. World Congress Proceeding. Tempere Finland. Pp 220.

Forest Foods as a Major Antidote to the Consequences of Hidden Hunger

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ABSTRACT

The study reviewed the relevance of forest foods as a major antidote to the negative consequences of Hidden Hunger. During the stone age, forest foods have been sources of nutrition and medicine to man and forest foods provide food from flora and fauna origin. The paper focuses on the health consequences of pregnant women, children and low income nations. It proffers solution from the point of forest foods in which at the different sections of the paper .The forest micronutrients compositions were presented as prevention to the health issues caused by hidden hunger. Global measures through which negative effects of hidden hunger could be curbed such as Scaling up Nutrition Movement, Nutrition for Growth Summit and Micronutrient initiative were also discussed . Findings showed that children must start life with their basic nutrition needs and their development potential protected. It is recommended that foods must be provided to ensure vulnerable people receive health and nutrition services in the most integrated way possible.

Keywords: Hidden hunger, forest foods, micronutrients, nutrition, medicine

INTRODUCTION

Forests and tree-based agricultural systems contribute directly and indirectly to the livelihoods of an estimated one billion people globally. Wild foods are important for food security and nutrition while trees and forests are vital for their role in the provision of ecosystem services to agriculture. The alarming expansion of large-scale industrial production systems in tropical regions threaten the contributions of forests and tree-based agriculture systems to food security, diets and nutrition in the tropical regions of the world in particular may threaten the potential contributions of forests to the food security, diets and nutrition of a growing world population. Despite this, the role of forests in supporting human food security and nutrition remain largely under-researched and understood. With food security and nutrition high on the agenda in many political and scientific spheres, it is crucial to understand the contribution of forests and trees to a food secure and nutrition-sensitive future. This improved understanding will be essential for building on synergies and minimizing trade-offs between biodiversity conservation and sustainable agriculture in order to feed an estimated global population of nine billion people by 2050 Sunderland (2011).

Forest foods combine foods from plant and animal origin. Plant foods are often classified into fruits and seeds, nectars and saps, stems and tubers, leaves and mushrooms. Animal sources can be of invertebrate (insects and insect larvae) or vertebrate (bush meat or fish) origin. Forest foods or "bush foods" are often associated with wild or uncultivated plants and animals. The dichotomy between "wild" and "domesticated" is, however, often artificial as the analysis of local farming systems in forested areas worldwide shows a continuum from subsistence foraging to commercial agriculture. There is no clear dividing line between foraging and agriculture.

Forest foods could as well be referred to as Non-wood forest products (NWFPs), Non-wood forest products have been defined as "all goods of biological origin other than wood in all its forms, as well as services derived from forest or any land under similar use." In many parts of the world, these products still play important biological and social roles in local food systems. They can contribute substantially to nutrition, either as part of the family diet or as a means to achieve household food security. They can also improve health through the prevention and treatment of diseases. Poor households residing in and around forest areas particularly landless people, women and children depend to a greater or lesser extent on the exploitation of common property forest resources in their everyday life or in periods of crisis.

HIDDEN HUNGER

Hidden hunger or chronic malnutrition can be defined as a low supply with essential micronutrients e.g. vitamins, minerals etc. Hidden because typical signs and symptoms of severe deficiencies are absent as long as a small amount of the micronutrients is present in the diet.(Konrad , 2014)

Currently, three billion people are affected by hidden hunger. In particular iron, iodine, zinc, vitamin A and D are the major candidates of hidden hunger. Year after year it is hidden hunger, not only the physical torture of starvation, which is responsible for the deaths of millions of men and women, but the majorities are children. Chronically malnourished women and children, most of all, are the ones who face the highest risk of suffering illness or death before having taken their first real steps in life. This is the real tragedy! Hidden hunger remains invisible over a more or less long period of life. Even in cases with adequate energy supply the missing micronutrients cause physical and cognitive impairment of the growing child. From the beginning of their life these children are captured in a vicious cycle of malnutrition and poverty. Poor physical strength and low educational level are the basis to remain in poverty and malnutrition. Poverty and chronic malnutrition are inseparable, and yet the connection is very often overlooked. (Konrad , 2014)

Hidden hunger can have the following negatives effects on the concerned individuals such as: illness, blindness, premature death and so on. Hidden hunger can also lead to illness, blindness, premature death, reduced productivity, and impaired mental development, particularly among women and children in developing countries. One out of three people in developing countries suffers from hidden hunger, which increases their vulnerability to infection, birth defects, and impaired development. People suffering from hidden hunger have diets that are deficient in micronutrients. They habitually eat large amounts of staple food crops (such as maize, wheat, and rice) that are high in calories but lack sufficient micronutrients, and low amounts of foods that are rich in micronutrients such as fruits, vegetables, and animal and fish products. People suffering from hidden hunger are often too poor to be able to afford foods that are more nutritious, or otherwise lack access to these foods.

MICRONUTRIENTS

Micronutrients are needed only in minuscule amounts; these substances are the ‘magic wands’ that enable the body to produce enzymes, hormones and other substances essential for proper growth and development. As negligible as the amounts are, however, the consequences of their absence are severe. Iodine, vitamin A and iron are most important in global public health terms; their lack represents a major threat to the health and development of populations the world over, particularly children and pregnant women in low-income countries.

Despite significant progress made in child survival responses, millions of children under the age of five continue to die from preventable causes, with malnutrition contributing to 45 percent of those deaths . For those who live, one quarter — approximately 165 million children — suffer from stunting, one of the most measurable signs of malnutrition (Ref). Stunting is what happens when a child’s brain and body do not have the right kind of food or nutrients to fully develop, particularly in the 1,000 days between conception and age 2. A stunted child is at greater risk of infection, disease and early death, and his future ability to learn and earn is irreversibly impacted.

A strong nutrition foundation is essential for building a strong immune system. It is also the starting point of any effective health system. With child mortality rates still unacceptably high and malnutrition such a significant contributor to these rates, it is obvious there is significant scope and opportunity to bring health and nutrition approaches closer together. The groups most vulnerable to micronutrient deficiencies are pregnant women, lactating women and young children, mainly because they have a relatively greater need for vitamins and minerals and are more susceptible to the harmful consequences of the deficiencies such as: a greater risk of dying during childbirth, giving birth to an underweight or mentally-impaired baby.

FOREST FOOD AS A SOLUTION TO THE CONSEQUENCIES OF HIDDEN HUNGER

Nutrients from Forest Foods

Forest foods provide a wide variety of nutrients: carbohydrates, such as starches, fructose and other soluble sugars, protein, fats and micro-nutrients (vitamins and minerals).

Tree Legumes and Human Nutrition

The seeds of the African locust bean (*Parkiaspp*), a perennial tree legume, are consumed in Africa, South-East Asia and tropical South America. In Malaysia and Indonesia, the whole pods, sometimes preserved by pickling in salt, are eaten raw or cooked as a vegetable known as *petai*. In West Africa, from Gambia to Cameroon, the beans of the Savannah species are widely fermented to the traditional *dawadawa* or *soumbara*, a nutritious protein (40 percent of dry matter) and fat (35 percent) rich food which keeps for over a year without refrigeration and is added to soups and grainporridges, while the vitamin-C rich pericarp called *dozim* is eaten by children raw or as a sweet drink. The beans mature in the dry season in February and March, providing valuable food in the middle of the traditional "hungry season" before the new harvest. Annual production figures are difficult to obtain since they do not enter regular commercial trade. It has however been estimated that 200,000 tons of beans are gathered each year in Northern Nigeria. In Nigeria, traditional home gardens contain at least 60 species of trees which provide food products (Okafor and Fernandes, 1987).

The fruit of the related carob tree is made into flour or beverage in the semi-arid Chaco region in South America. Prepared as *Patay*, it has a high content of absorbable calcium. The deep roots of *Parkia* trees needed to find underground water provide a reliable annual crop even in the lean, drought years where herbaceous plants and cultivated crops fail to grow.

The negative effects from the inability of taking sufficient micronutrients from the intrauterine development, the growing stage of a child and up to adulthood stage have a lot of medical or health issues or consequences. This is not far-fetched from the poverty level of the individual, shortage of food and high cost of these necessary micronutrients which is supposed to form the basis of an individual food intake.

Table 1: Nutrients composition of edible fruits and vegetables of forest species

Species	Edible part	Calories	% fresh weight (unless otherwise stated)				Mg per 100 g fresh weight (unless otherwise stated)			Vitamin A (in international units)	Thiamin (kg gamma)	Riboflavin (kg gamma)
			Water	Protein	Fat	Carbohydrate	Ca	Fe	Nicotianic acid	Ascorbic acid			
Annona muricata	fruit pulp												
Artocarpus communis	fruit pulp	109	70	1.5	0.3	25	25	1.0	-	15	35	200	-
Carica papaya	fruit pulp	38	89	0.6	-	9	10	0.5	0.1	60	2500	20	20
Cola acuminata	nut	309	12	9.0	1.0	66	-	-	0	-	-	-	-
Cola nitida	nut	-	83	1.5	0.6	-	3.1	1.4	0.7	9.8	31	11	47
Daniellaoliveri	dried leaves		9.4	5.5	-	-	-	-	-	-	-	-	-
Ficusgnaphalocarpa	dried leaves	-	11.6	13.8	-	-	-	-	-	-	-	-	-
Irvingiagabonensis	dried kernel	-	-	-	54	-	-	-	-	-	-	-	-
Monodoramyristica	residual seed meal	212	1.0	17.6	2.8	29	-	-	-	-	-	-	-
Moringaol	fresh												

eifera	seeds												
Moringaoleifera	fresh leaves												
Pentracletahrasacrophylla	kernel	569	10	22	45	17	90	-	-	-	-	-	-
Prosopisafricana	pod pulp	279	9.6	9.2	3	53	160	70	-	-	-	-	-
Prosopisafricana	dried stems + leaflets	300	7.9	10.2	6.8	50	-	-	-	-	-	-	
Pterocarpusspp	dried leaves	218	10.1	17.1	2.4	32	500	70	-	-	-	-	-
Spondiasmombin	fruit pulp	-	72.8	1.3	0.1	-	31.4	2.8	0.9	46.4	71	95	50
Telfariapedata	kernel	517	6.6	19.6	36	28.5	-	-	-	-	-	-	-
Vitexdoniana	dried leaves												

Source: Ody,1993

GLOBAL MEASURES DESIGNED TO AMELIORATE HIDDEN HUNGER

Scaling up Nutrition Movement: The system was designed in 2009 (By who?) on the principle of ensuring good nutrition for all if the world's biggest challenges of hunger are to be overcome.Presently,there is good news on this front. At long last, it is witnessing an increase in political will towards improving global nutrition, both from donor countries and developing nations. There are now 53 countries that have signed on to the Scaling up Nutrition Movement.

Nutrition for Growth Summit : In 2013, the United Kingdom brought world leaders together to address hunger and improve global nutrition. Most recently, nutrition was at the forefront of Canada's" Saving Every Woman, Every Child: Within Arm's Reach Summit," where world leaders and experts gathered to determine new ways to stop children and women dying from a lack of access to basic and inexpensive solutions. Canada committed$3.5 billion over five years, on improving nutrition, particularly for women and children in developing countries, as a key pillar. These political events were exemplary at highlighting the role of nutrition for the survival and development of the world's children, yet the final goal of ending preventable deaths for women and children continues to elude us because there are missed opportunities in our global efforts.

Micronutrient Initiative: It is a global nutrition organization that reaches 500 million people in more than 70 countries every year. The president of the initiative, Joel Spicer had his background in public health and has worked previously with UNICEF, WHO and World Bank. The main objectives of this initiative are how the Micronutrient Initiative could add the most value possible and remove missed opportunities. Missed opportunity comes to place if we provide vitamin A every six months and do not harness that platform effectively for deworming or other interventions, that's a missed opportunity. Or when we successfully treat a child for severe acute malnutrition only to have them back on treatment again six months later because they're not getting the ongoing community-based nutrition support they need, that is a missed opportunity. And when we don't take advantage of social protection or school feeding programs to deliver everything they can for women and children, and in particular for adolescent girls, that is a missed opportunity.

CONCLUSION

From the findings, it reveals that all of us are accountable and responsible for missed opportunities in global health .We know that the effectiveness of many public health interventions is compromised by poor underlying nutritional status. Children must start life with their basic nutrition needs met and their development potential protected. More must be done to ensure vulnerable people receive health and nutrition services in the most integrated way possible. We can and must eliminate missed opportunities in the spaces between nutrition and health, and nutrition and other sectors.

REFERENCES

The World Health Report 2001: Reducing risks, promoting healthy life. Geneva, World Health Organization, 2001.

UNICEF/UNU/WHO. Composition of a multi-Micronutrient supplement to be used in pilot programmes among pregnant women in developing countries. Report of a Workshop. New York, UNICEF, 1999.

FAO/WHO. Vitamin and mineral requirements in human nutrition, 2nd ed.Geneva, World Health Organization, 2005.

Konrad, 2014: Bread and Brain, Education & Poverty . Pg. 1-24

Sundeland, TCH (2011): Food security: Why biodervisity important? *International forestry Review* 13 (3) online.

WFP. Nutrition in Emergencies WFP Experiences and challenges andMicronutrient fortification: WFP experiences and ways forward.

WFP Policy papers May 2004.Institute of Medicine. Food and Nutrition Board Dietary reference intakes. Application in dietary assessment. A report of the Subcommittee on Interpretation and uses of dietary reference intakes and the Standing Committee on the Scientific Evaluation of Dietary Reference Intakes. National Academic Press, Washington D.C., 2001.

WHO/MI. Safe vitamin A dosage during pregnancy and lactation. Recommendations and report of a consultation. Geneva, World Health Organization,1998. (WHO/NUT/98.4).

Indicators for assessing vitamin A deficiency and their application in monitoring and evaluating intervention programmes. Geneva, World Health Organization, 1996 (WHO/NUT/96.10).

WHO/UNHCR. Pellagra and its prevention and control in emergencies. Geneva, World Health Organization, 1999(WHO/NHD/99.10).

WHO/UNHCR. Scurvy and its prevention and control in emergencies. Geneva,World Health Organization, 1999 (WHO/NHD/99.11).

WHO/UNHCR. Thiamine deficiency and its prevention and control in major emergencies. Geneva, World Health Organization, 1999 (WHO/NHD/99.13).

WHO/UNICEF/ICCIDD. Assessment of iodine deficiency disorders and monitoring their elimination. 2nd ed. Geneva, World Health Organization, 2001 (WHO/NHD/01.1).

WHO/UNU/UNICEF. Iron deficiency anaemia. Assessment, prevention and control. A guide for programme managers. Geneva, World Health Organization, 2001 (WHO/NHD/01.3).

FAO/IAEA/WHO: Trace elements in human nutrition and health. W.H.O.Geneva. 1996

Influence of Lignocellulosic Particles and Resin Content on Sorption Characterization of Urea Formaldehyde-Tannin Modified Resin Bonded Board

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ABSTRACT

The study investigated the influence of production variables on sorption properties of urea formaldehyde–tannin modified resin bonded board produced from wood and agro residue particles. The tannin was extracted from the bark of Anogenssus leiocarpus using aqueous extraction method and added to urea formaldehyde resin prior to board production. The experimental design was 5 x 3 factorial experiment in Completely Randomized Design. Variables assessed include resin yield and stiasny number, water absorption (WA) and thickness swelling (TS). Data obtained were subjected to Analysis of Variance. The percentage yield and stiasny number of the tannin extracted was 26.67% and 47.28% respectively. The result revealed that WA and TS ranged from 33.84±6.46% to 72.95±10.92% and 2.06±0.66% to 6.07±2.22% respectively. After 24hrs immersion in water, WA observed for boards produced with wood particle was 72.9% significantly higher than 33.84% absorbed by rice husk board. Boards produced with bean chaff particles had significantly higher TS of 6.07% than boards produced with rice husk which had the lowest TS of 2.06%.WA and TS decreased with increase in resin blending proportion from 20% to 30%. Board produced with rice husk at 30% blending proportion with urea formaldehyde tannin resin was the most dimensionally stable board. Potential and effective utilization of agro residual wastes particularly rice husk could substitute wood raw materials in the production of particleboards and other wood products. This will afterwards reduce pressure and dependence on forest and forest resources overtime.

Keywords: Lignocellulosic; tannin; Urea formaldehyde; sorption; particleboard

INTRODUCTION

The demand for raw material by the forest industry has continued to grow. On one hand, approximately 95% of all ligno-cellulosic material available for particleboard production is wood (Habibi *et al*., 2008) on the other hand, forests, the major sources of wood supply are been depleted at the alarming rate of 13.0 million ha each year in developing countries (Ashori, 2003). Mamza, (2010) opined that the over reliance on natural solid wood for fuel, construction material and other wood works, and subsequently generation of wood wastes such as sawdust from wood processing, pose great challenges to environmental sustainability. This has inevitably led to uncontrolled forest exploitation, which has resulted into loss of forest and forest estates and consequentially, climate change. Rafael *et al.*, (2014) further posit that owing to the rise in wood consumption, the reserves of native woody species is on the decrease, causing the search for new renewable lignocellulosic materials that may efficiently meet the demand.

A large volume of agro wastes are produced annually all over the world. If these wastes are left unattended to, they tend to occupy fertile and useful lands and poses serious environmental and health problems. Oftentimes, they are burned in landfills which further results in increased amount of greenhouse gases in the atmosphere. Therefore attempts are being made to convert these wastes into valuable materials. Developing particle boards out of these wastes has been tried world over (Narendar, and Priya 2012). Utilization of alternative resources such as the fast growing species like kenaf and bamboo are been encouraged. Many studies have been conducted to utilize agricultural plant-fiber residues in the forest product industry as raw material components in composite products in several countries (Nikvash *et al*., 2010).

In addition, low cost, curing at low temperature, water solubility and lack of color of the cured resin are some of the merits of using UF resin. On the other hand, concern about emission of formaldehyde and weakening glue bond initiated by hydrolytic degradation of UF polymers have brought about the development of improved and modified UF adhesive system (Chung-Yun *et al*., 2008; Puttasukkha *et al*., 2015).

The different methods for reducing the formaldehyde emission for wood composite products include modification of resin formula, usually be the reduction of formaldehyde-urea molar ratio or mixing of UF resin with other resins such as tannin (Quea *et al*., 2007), addition of formaldehyde scavenger to the UF resin or wood furnish (Moubarik *et al*., 2013), changing the pressing parameters such as pressing time or pressing temperature increasing (Petinarakis and Kavvouras 2006), treating of finish boards, generally posing with ammonium gas or surface processing with formaldehyde scavenger solution (Roffael 2011) and changing to an entirely different adhesive system (Wanga *et al*., 2007). With the tannin-formaldehyde adhesives, panels can be manufactured with improved physical and mechanical properties. The aim of this study is therefore to investigate the influence of lignocellulosic particles and percentage resin content on dimensional stability properties of urea formaldehyde-tannin modified resin bonded board

MATERIALS AND METHOD

The experiment was carried out in Federal College of Forestry Jos, Plateau State Nigeria. Wood (*Anogenssus leiocarpus*), bagasse, rice husk groundnut shell and bean chaff particles, urea-formaldehyde resin and tannin bark extract of *Anogenssus leiocarpus* wood were used in production of one-layer particleboard.

Aqueous Extraction of Tannin

The barks of *Anogenssus leiocarpus* were collected and air-dried to 12% moisture content and cut into small chips. The barks were then ground in a Wiley mill into a powder and sieved to pass through 0.5 µm mesh. For the extraction process, the method reported by Barminas and Osemeahon (2006) was adopted. 300g of the plant powder was weighed into 500ml conical flask and was soaked in distilled water. This was left to stand overnight (24hrs) and was agitated for 3hrs in a mechanical shaker. The content was filtered using a nonabsorbent cotton wool on a Buchner funnel / flask using a vacuum pump. The residue was subjected to several parts of rinsing and filtration with fresh solvents to attain some level of exclusive maceration (extraction). The collected filtrate was evaporated to dryness using a water bath and a drying cabinet. The percentage yield of the extract (tannin content) was determined and the extract transferred into a stirrer samples container and kept in the refrigerator for further use.

Board formation

The board production was based on standard procedures from previous related studies according to Hashem, (2013) and Bahrinejad and Abolghasem (2014). The particles were milled, air dried to reduce the moisture content to 12% and subsequently screened using 2.00µm sieve. The particles, urea formaldehyde and tannin bark extract were measured based on the selected density (800kg/m^2) and volume of the mould (350 x 350 x 6mm^3). 10% tannin bark extract was added to the water prior to mixing to serve as urea formaldehyde modifying additive. The materials were homogenously mixed together based on percentage urea formaldehyde resin content of 20%, 25% and 30% on dry solids particle weight basis. After a homogenous mixture was obtained, the particle mix was transferred to the mould under laid with cellophane lubricated with engine oil to prevent sticking of the board on the mould. After pouring the particle mix in the mould and pre pressed, the formed mat was overlaid with lubricated cellophane to also prevent adhesive from sticking to the cover and also for easy demoulding. The formed mat was placed inside the compression cold press and pressed for 3 days with exert pressure of 1.23N/mm^2 from a hydraulic jack. The boards were thereafter removed from the cold press, demoulded, conditioned for 3 days and taken back to the cold press to straighten out and prevent folding of the boards. The edges of the final board were trimmed and the samples were cut for properties evaluation.

Experimental Design

The experimental design was 5 x 3 factorial experiment in Completely Randomized Design (CRD) replicated 5 times. These include 5 particle types (wood, bagasse, rice husks, ground nut shell, and bean chaff) and three (3) percentage resin content (20%, 25% and 30%).

Parameters Assessed and Statistical Analysis

Quantitative test

The quantitative test to determine the extract yield and stiasny number of tannins was carried out according to method described by Antwi-Boasiako and Animapauh (2012).

Sorption Properties

Board samples of 50 mm × 50 mm × 6 mm were used to determine the dimensional stability test (Water Absorption (WA) and Thickness Swelling (TS)) according to American Society for Testing Materials (ASTM) standard (2005). The boards were immersed in distilled water for 24 hrs. The changes in weight and thickness of the samples were measured before and after immersion in water and calculated in percentages. Data obtained were subjected to analysis using analysis of variance with further comparisons by Duncan Multiple Range Test (DMRT)

RESULTS AND DISCUSSION

RESULTS

Quantitative Test of Tannin Extract

The percentage yield and Stainsy number of the tannin extracted from *Anogenssus leiocarpus* as presented in Figure 1 were 26.67% and 47.28% respectively. Higher Stiasny number indicates great tannin content, while a low extract yield implies that the solvent could not remove much or all the extracts in the plant material

Effects of Particle Type and Resin Content on Sorption Characterization of Urea Formaldehyde-Tannin Modified Resin Bonded Board

The effects of particle type on sorption characterization of the urea formaldehyde-tannin modified resin bonded board after 24hrs immersion in water as presented in Figure 2 revealed wood particle absorbed the highest (72.9%) volume of water, while rice husk absorbed the least (33.84%) quantity of water. The water absorption of bean chaff, bagasse and groundnut shell particles were 48.2%, 37.8% and 36.2% respectively. On the aspect of thickness swelling, Bean chaff particles had the highest (6.07%) increase in dimensional thickness while rice husk had the lowest (2.06%) thickness swelling after 24hrs immersion in water. The thickness swelling of wood, groundnut shell and bagasse were 4.27%, 3.18% and 2.10% respectively. The above findings invariably implies that particleboard produced with rice husk is the most dimensionally stable board due to the fact that it absorb least moisture thereby reduced board weight and thickness.

The effect of resin blending proportion on the Water Absorption (WA) and Thickness Swelling (TS) of the Resin Bonded Particleboard after 24hrs immersion in water shown on Figure 3 revealed that 20% Blending Proportion had the highest WA (53.5%) and TS (5.0%), while 30% Blending Proportion had the lowest WA (39.4%) and TS (2.3%). This laid credence to that fact that the higher the adhesive Blending Proportion, the lower the WA and TS of the board produced. As such the more dimensionally stable the board, the more its resistance to absorb water and increase in thickness.

The Analysis of Variance for Water Absorption of the urea formaldehyde-tannin modified resin board after 24hrs immersion in water as shown in Table 1 revealed that the particle type (PT: p(0.001)) and blending proportion (BP: p(0.001)) had significant effects on the WA of the board at 5% probability level, while the Two-factor interaction of the PT and BP (PT*BP: p(0.688)) had no significant effects on the WA of the board at 5% probability level. In the same manner, particle type (PT: p(0.001)) and blending proportion (BP: p(0.001)) had significant effects on the Thickness Swelling of the board ($p \leq 0.01$). The Two-factor interaction of the particle type and blending proportion (PT*BP: p(0.001)) had significant effect on the TS of the board (Table 2).

The result of the Duncan's Multiple Range Test (DMRT) for sorption characterization of the urea formaldehyde-tannin modified resin bonded board as affected by particle type is shown in Table 3. As observed in this result, for the fact that there was significant difference between wood and rice husk particles, rice husk particle had the lowest significant effect on WA of the board produced. Wood particle on the other hand had the highest significant effects on WA of the board produced. Effects of particle types on thickness swelling revealed that the effect of bean chaff and rice husk were significantly different on the TS of the board produced. While bean chaff recorded the highest (6.07%) significant effect, rice husk indicated the lowest (2.06%) significant effects. Significant differences exist in the effects of resin blending proportion on WA and TS for Blending Proportion 20% and 25%; 20% and 30%; and 25% and 30% after 24hrs immersion in water (Table 4).

Based on the above observed occurrences, it can be inferred that particle type and blending proportion have significant effects on the sorption characterization (WA and TS) of the urea formaldehyde-tannin modified resin bonded board after 24hrs immersion in water.

DISCUSSION

Quantitative Test of Tannin Extract

The tannin yield extracted from *Anogenssus leiocarpus* was 26.67% while the percentage Stainsy number was 47.28%. The tannin yields were quite lower using distilled water as solvent than expected, considering the work of earlier researchers. The use of autoclaves by Ferreira *et al*., (2008) with water produced tannins of 60-65% from *Pinus ocarpa* bark. The use of water solvent as medium of extraction has its own merits. Antwi-Boasiako and Animapauh, (2012) affirmed that distilled water is a good alternative possibly at a lower cost in extracting tannin from barks of hardwoods. This is also confirmed by Dametey (2010) who discovered aqueous extraction to be very efficient in removing tannins from *Acacia mangium* and *A. auriculiformis barks* as well as *Pinus ocarpa* leaves. Stiasny reaction (which also indicates condensed tannins) gives an indication of the number of reactive tannins in an organic material (Derkyi *et al*., 2011). Higher Stiasny number indicates great tannin content. The stiasny number (47.28) as obtained in this study was a little bit higher than the value of 46% obtained by Ping *et al*., (2011) on extraction of condensed tannins from grape pomace for use as wood adhesives.

Effects of Particle Type and Resin Content on Sorption Characterization of Urea Formaldehyde-Tannin Modified Resin Bonded Board

Water Absorption and Thickness Swelling as presented in Table 1 ranged from 33.84±6.46% to 72.95±10.92% and 2.06±0.66% to 6.07±2.22% respectively. It is worth mentioning that according to EN standards, the maximum thickness swelling after 24h of soaking in water for load-bearing and heavy-duty load bearing applications are 15% and 14% respectively (EN 312, 2005) and for panels type P3, non-load bearing, to be used in humid conditions is 17% (EN312, 2010). None of the tested particleboards had TS above the standard requirement, thus acceptable.

The results obtained from this study agree and also contradicts findings of similar studies. Kord *et al*., (2016) evaluated the mechanical and physical properties of particleboard manufactured from Canola (*Brassica napus*) Straws using unmodified UF. Ugur *et al*., (2015) on the other hand investigated the effects of ammonium nitrate on physico-mechanical properties and formaldehyde contents of particleboard. The values of WA obtained by these researchers were similar to values obtained in this study. Kord *et al*., (2016) obtained minimum and maximum values of WA of 35.7% and 70.9% respectively, while Ugur *et al*., (2015) reported a range of 41.75 to 54.89 % for WA. Similarly, Lina, *et al*., (2013) in their study on relation of transverse air permeability with physical properties in different compositions of sugarcane bagasse particleboards reported a range of 34% to 64% for WA. Conversely, the range of values of TS (2.06 to 6.07%) obtained in this study is less than TS (10.18-27.48%) documented by Kord *et al*., (2016), 7.53 to 12.93 % recorded by Ugur *et al*., (2015), and 11.5% to 24.2% reported by Lina *et al*., (2013). The use of ammonium nitrate for particleboard manufacturing resulted in improved water absorption and thickness swelling properties after 24 h of immersion in water (Ugur *et al*., 2015). Elbadawi *et al*., (2015) in their assessment of the properties of particleboards made from acacia seyal var. Seyal using uf–tannin modified adhesives reported higher range of values than values obtained in this study. They reported WA ranging from 78.58% to 87.05% and TS ranging from 22.14% to 25.99%. Based on these occurrences, it could be affirmed that the modification of the urea formaldehyde with tannin contributed to the improvement of the dimensional stability of the boards produced in this study.

Boards produced from wood particle had the significantly highest WA and TS compared to the other agro residual particles, while rice chaff recorded the least making it the most dimensionally stable board. This observed is contrary to assertions which identified particular particles as a material with high lignin content with low affinity for moisture which thus, act as a barrier for cellulose microfibril. Coconut husks fibre with 29.79% lignin content (Pilanee *et al*., 2011) is hydrophilic due to the presence of hydroxyl groups from cellulose and lignin components. Differing from the aforementioned assertion, Désiré *et al*., (2011) reported the lignin content of *Anogeissus leiocarpus* as 26.67% which is higher than the lignin content of rice chaff (20.9%), bagasse (10.51% -Martin *et al.*, 2007), bean chaff (9-11% - Dinsdale *et al*., 1996) but less than the lignin content of groundnut shell (30.2% - Raju and Kumarappa, 2011). Yet the wood particle recorded the highest WA.

Water absorption behaviour of natural fibres also depends on free hydroxyl groups present in cellulose and hemicelluloses, which are accessible by water. Besides that, other factors such as porosity, void content, lumen size, and fibre-matrix adhesion also effect water absorption behaviour of the composites (Mariatti *et al*. 2008; Chiang *et al*., 2016). Consequently, high cellulose content in *Anogeissus leiocarpus* compared to low cellulose content in rice husk may contribute to more water penetrating into the interface, through the micro cracks induced by swelling of fibers, creating swelling stresses leading to composite failure. The water molecules actively attack the interface, resulting in deboning of fibre and matrix. Another reason for the high WA observed in wood can be attributed to the combination of the lower particle sizes of the agro residual particles and the modification of the urea formaldehyde with tannin. Emmanuel *et al*., (2012) deduced that increased particle size resulted in more void space during consolidation resulting in higher porosity and easier diffusion of water into boards during soaking.

The results further exhibited that the WA and TS significantly decreased with increase in resin content from 20% to 30%. The addition of tannins to UF adhesive reduced the physical properties of the boards. The mixing of different proportions of tannins with UF led to a decrease in the TS when the tannins percentage increased after 24 h water soaking test (Elbadawi *et al*., 2015; Boran *et al*., 2012). Yong *et al*., (2011) adduced this to the chemical components in the resin that is capable to cross-link with the hydroxyl groups of the fibers, hence reducing the hygroscopicity of the boards. More adhesive added to particle means that greater area of particles is covered with adhesive. If greater area is covered by adhesive that also means that particles are more bonded together, hence less water can penetrate between particles.

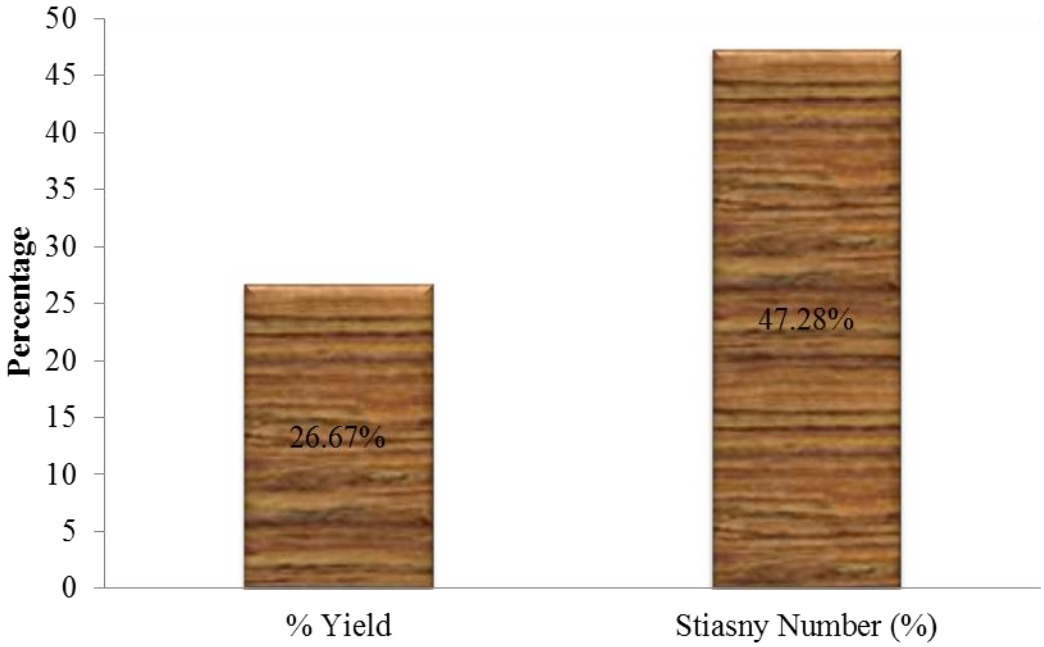


Figure 2: Percentage Tannin Yield and Stiasny Number

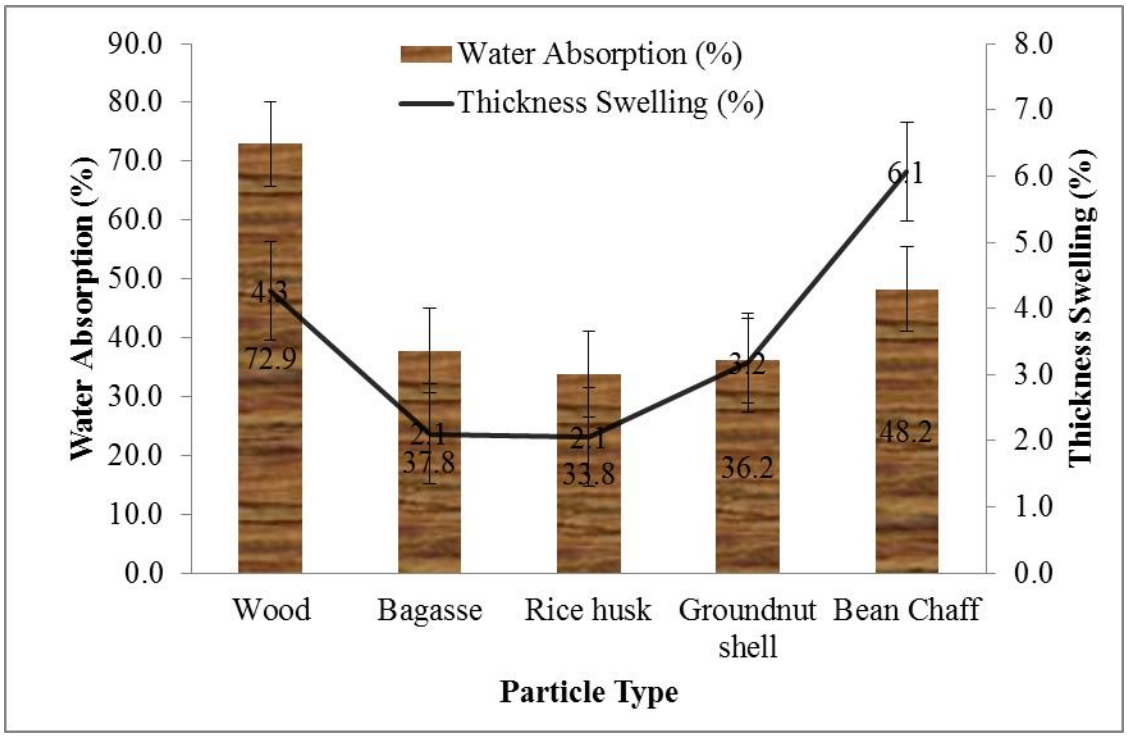


Figure 2: Effects of Particle Type on Sorption Characterization of the Urea Formaldehyde-Tannin Modified Resin Bonded Board

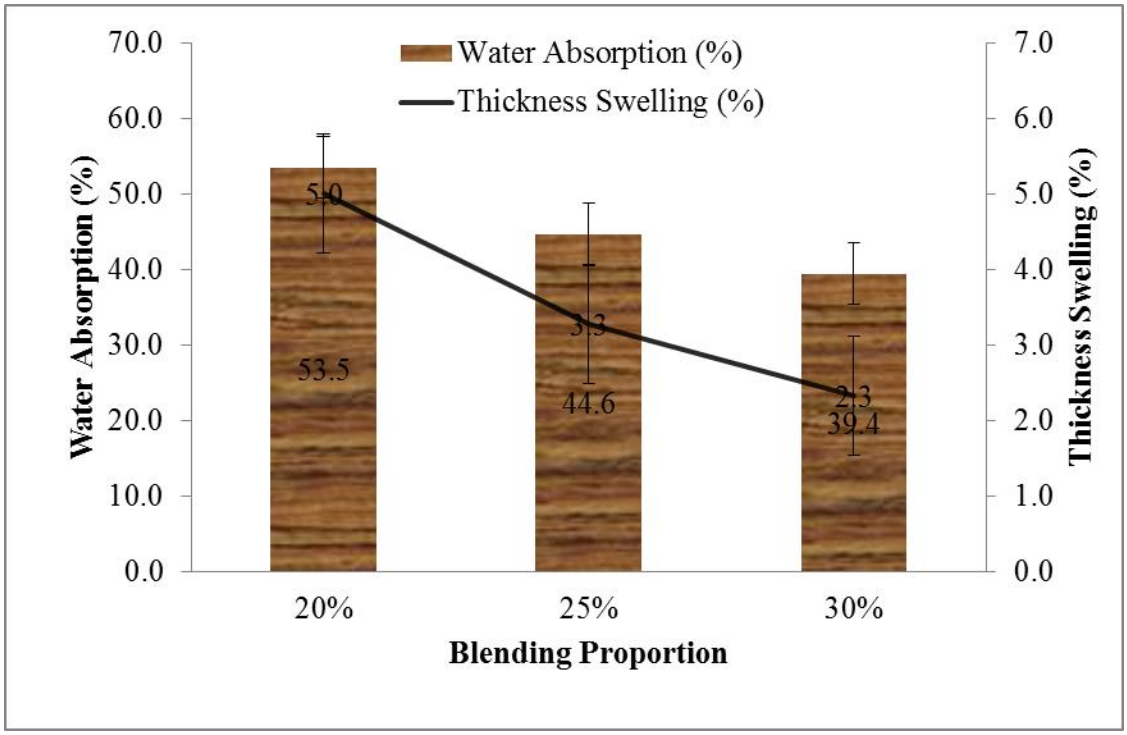


Figure 3: Effects of Blending Proportion on Sorption Characterization of the Urea Formaldehyde-Tannin Modified Resin Bonded Board

Table 1: Analysis of Variance for Water Absorption of the Urea Formaldehyde-Tannin Modified Resin Bonded Board

Source	Sum of Squares	df	Mean Square	F	Sig.
Particle Type (PT)	9376.53	4	2344.13	61.145	0.001*
Blending Proportion (BP)	1520.43	2	760.21	19.830	0.001*
PT * BP	215.13	8	26.89	0.701	0.688ns
Error	1150.12	30	38.34		
Total	12262.20	44			

**** significant*** ***ns not significant***

Table 2: Analysis of Variance for Thickness Swelling of the Urea Formaldehyde-Tannin Modified Resin Bonded Board

Source	Sum of Squares	df	Mean Square	F	Sig.
Particle Type (PT)	101.75	4	25.44	68.474	0.001*
Blending Proportion (BP)	55.24	2	27.62	74.355	0.001*
PT * BP	13.46	8	1.68	4.531	0.001*
Error	11.14	30	0.37		
Total	181.60	44			

**** significant***

Table 3: DMRT for Sorption Characterization of the Urea Formaldehyde-Tannin Modified Resin Bonded Board as affected by Particle Type

Particle Type	Water Absorption (%)	Thickness Swelling (%)
Wood	72.95±10.92[a]	4.27±1.05[b]
Bagasse	37.84±5.59[c]	2.10±0.76[d]
Rice husk	33.84±6.46[c]	2.06±0.66[d]
Groundnut shell	36.18±7.63[c]	3.18±1.70[c]
Bean Chaff	48.24±10.50[b]	6.07±2.22[a]

Means in the same column having different superscripts are significantly different (p≤0.05)

Table 4: DMRT for Sorption Characterization of the Urea Formaldehyde-Tannin Modified Resin Bonded Board as affected by Blending Proportion

Blending Proportion	Water Absorption (%)	Thickness Swelling (%)
20%	53.46±16.57[a]	5.00±2.30[a]
25%	44.57±17.25[b]	3.28±1.49[b]
30%	39.39±13.97[c]	2.33±1.24[c]

Means in the same column having different superscripts are significantly different (p≤0.05)

CONCLUSION AND RECOMMENDATION

Based on the results obtained from the present study, it was revealed that *Anogenssus leiocarpus* wood particles, and agro residual particles are suitable raw material for the production of urea formaldehyde-tannin modified resin bonded board. The study has been able to ascertain that modifying urea-formaldehyde with tannin produced excellent adhesive for manufacturing particleboard for interior use, as it improved its poor water resistance characteristics. Boards manufactured met the maximum physical properties requirements for European Committee for Standardization (EN). In general, board produced with rice husk was the most dimensionally stable in terms of particle type and percentage resin content.

As a renewable material, the utilization of rice husk can eliminate landfill waste disposal and enhance protection of the environment. Though the country rice production capacity is still low, but the advocacy for the country to look inward and increase its rice production capacity invariably implies that more residual rice husk waste will be generated. With the result of this finding, rice husk could serve as an alternative for wood raw material in the production of particleboard. Consequently environmental pollution through emission of methane and CO_2 gas during burning and dumping in landfills will be reduced. Also it will enhance sustainability of forest and forest resources by reducing dependence on the forest for raw material.

REFERENCES

American Society for Testing and Materials, (2005): American Society for Testing and Materials. Annual book of ASTM standards. 100 Barr Harbor Dr., West Conshohocken, PA 19428, ASTM D570-98, reapproved in 2005, p.35-37

Antwi-Boasiako, C and Animapauh, S.O. (2012): Tannin extraction from the barks of three tropical hardwoods for the production of adhesives. Journal of Applied Sciences Research, 8(6): 2959-2965.

Ashori, A. (2006): Non-wood fibers – A potential source of raw material in papermaking. Polymer–Plastic Technology and Engineering, 45(10): 1133–1136.

Bahrinejad, A. and Abolghasem, K. (2014): Effect of tobacco stalk on the physical and mechanical properties of particleboard. World of Sciences Journal. Vol 2 (1) Pp: 72-81

Barminas, J.T. and Osemeahon, S.A. (2006): Development of amino resins for paint formulation. Effect of temperature on new synthetic route. European Journal of Scientific Research, 14: 489-499.

Boran S, Usta M, Ondaral S. and Gumuskaya E (2012): The efficiency of tannin as a formaldehyde scavenger chemical in medium density fiberboard. Compos B Eng 43:2487–2491

Chiang, T.C., Hamdan, S. and Osman, M.S. (2016): Urea formaldehyde composites reinforced with Sago fibres analysis by FTIR, TGA, and DSC," Advances in Materials Science and Engineering, vol. 2016, Article ID 5954636, 10 p

Chung-Yun H., Feng F. and Hui P. (2008): Melamine-modified urea formaldehyde resin for bonding particleboards. *Forest Products Journal*. Vol. 58 (4). pp56 - 61

Dametey, E.A., 2010. The tannin percentages in four tree species: *Pinuscaribaea*, *Pinusoccarpa*, *Acaciamangium* and *Acaciaauriculiformis*, (Unpublished: BSc Thesis Presented to the Faculty of Renewable Natural Resources, Kwame Nkrumah University of Sc. &Technology), 43.

Derkyi, S.A., B. Adu-Amankwa, D. Sekyere and N.A. Darkwa, (2011): Application of Near Infrared Spectroscopy in ChemometricModeling of Tannin Content and Stiasny Number of *PinusCaribaea* Bark. *A Journal of Emerging Trends in Engineering and Applied Sciences* (JETEAS), 2(1): 132-136.

Désiré, F., Martin, N.T., Legrand, N.G., Pierre, N. and Mike, L. (2011): Nutritional status of forage plants and their use by elephant in Waza national park, Cameroon. Scientific Research and Essays Vol. 6(17), pp. 3577-3583

Dinsdale, R.M., Hawkes F.R. and Hawkes D.L. (1996): The mesophilic and thermophilic anaerobic digestion of coffee waste containing coffee grounds. Wat Res 30 (1996) 371-377

Elbadawi, M., Osman, Z., Paridah, T., Nasroun, T. and Kantiner, W. (2015): Properties of particleboards made from acacia seyal var. Seyal using uf–tannin modified adhesives. Cellulose chemistry and technology, 49 (3-4), 369-374

Emmanuel, A., Brain, K.V. and Oladiran, F. (2012): Effect of Microcrystalline Cellulose, Species and Particle size on Mechanical and Physical Properties of Particleboard. Wood Science and Fiber Science, 44 (2), pp1-9

EN 312 (2005): Particleboards specifications. Part 2: Requirements for general purpose boards for use in dry conditions. Institute of Turkish Standards. Ankara

EN312 (2010). Particleboards - Specifications. CEN, European Committee for Standardization, Brussels, Belgium, pp. 18.

Ferreira, S.E., C.C.R. Lelis, O. Brito Ede and S. Iwakiri, 2008. Use of tannins from *Pinusocarpa*bark for manufacture of plywood, *Proceedings of the 51st International Convention of Society of Wood Science and Technology*, November 10-12, 2008 Concepcion, Chile.

Habibi Y, E., Zawawy W.K., Ibrahim M.M. (2008): Dufresne A. Processing and characterization of reinforced polyethylene composites made with lignocellulosic fibers from Egyptian agro-industrial residues. Compos SciTechnol 2008;68(7–8):1877.

Hashem, R., Mehrab, M., Adeleh, E. and Farshid, F. (2013): Effect of resin content, press time and overlaying on physical and mechanical properties of carton board made from recycled beverage carton and MUF resin. Life Sci J 2013;10(4s):613-619] (ISSN:1097-8135).

Kord, B., Zare, H. and Hosseinzadeh, A. (2016): Evaluation of the Mechanical and Physical Properties of Particleboard Manufactured from Canola (Brassica napus) Straws. Maderas. Ciencia y tecnología 18(1): 9–18

Lina, B., Lourival, M., Mendes, G., Henrique, D.T., Mário, V.S., José, R., Moreira da Silva and Fábio A.M. (2013): Relation of Transverse Air Permeability with Physical Properties in Different Compositions of Sugarcane Bagasse Particleboards. *Materials Research*.; 16(1): 150-157

Mamza, P.A.P. Aliu, A. Muhammed, R.A. (2010). The effects of iron filling on some mechanical and physical properties of sawdust particleboard. Nigerian Journal of basic and Applied Science,18(1):112-119.

Mariatti, M., Jannah, M., Bakar, A. A., and Khalil, H. (2008): Properties of banana and pandanus woven fabric reinforced unsaturated polyester composites. Journal of Composite Materials 42(9), 931-941.

Martin, C., Alriksson, B., Sjöde, A., Nilvebrant, N.O. and Jönsson, L.J. (2007): Dilute sulfuric acid pretreatment of agricultural and agro-industrial residues for ethanol production. Appl. Biochem. Biotechnol. 136-140: 339-352.

Moubarik, A., Mansouri, H.R., Pizzi, A., Allal, A., Charrier, F., Badia, M.A., Charrier, B., 2013: Evaluation of mechanical and physical properties of industrial particleboard bonded with a corn flour–urea formaldehyde adhesive. Composites Part B 44(1): 48-51.

Narendar, R and Priya Dasan.K (2012): Recent Developments In Coir Pith Based Particle Boards: A Review. International Journal of Recent Scientific Research, Vol. 3, Issue, 2, pp. 91 -94

Nikvash, N., Kraft R., Kharazipour, A., & Euring, M. (2010): Comparative properties of bagasse, canola and hemp particle boards. Eur. J. Wood Prod., 68(3), 323-327.

Pilanee, V., Waraporn, A., Nanthaya, C., Wuttinunt, K. and Sarima, S. (2011): The Potential of Coconut Husk Utilization for Bioethanol Production. Kasetsart J. (Nat. Sci.) 45: 159 – 164

Ping, L., Brosse, N., Chrusciel, L., Navarrete, P., Pizzi, A., (2011). Extraction of condensed tannins from grape pomace for use as wood adhesives. Ind. Crop. Prod.33, 253–257.

Puttasukkha, J., Khongtong, S. and Chaowana, P. (2015): Curing behavior and bonding performance of urea formaldehyde resin admixed with Formaldehyde scavenger. Wood Research. 60 (4): 645-654

Quea, Z., Furuno, T., Katoh, S., Nishino, Y., 2007: Evaluation of three test methods in determination of formaldehyde emission from particleboard bonded with different mole ratio in the urea–formaldehyde resin. Building and Environment 42(3): 1242-1249.

Rafael, R., Diego, M.S., Ricardo, R.C. and Talita, D.P. (2014): Physical and mechanical properties of particleboard manufactured from wood, bamboo and rice husk. Material Research vol.17 no.3 São Carlos. ISSN 1516-1439

Raju, G.U. and Kumarappa, S. (2011): Experimental study on mechanical properties of groundnut shell particle-reinforced epoxy composites. J Reinf Plast Compos 30(12):1029–1037.

Roffael, E., 2011: On the responsiveness of hardened UF-resins of different molar ratio towards ammonia fumigation. European Journal of Wood and Wood Products 69(4): 675-676

Ugur A., Kalaycioglu, H., Yel, H. and Bitek, G. (2015): Effects of Ammonium Nitrate on Physico-mechanical Properties and Formaldehyde Contents of Particleboard. World Conference on Technology, Innovation and Entrepreneurship. Procedia - Social and Behavioral Sciences 195 (2015) 2130 – 2134

Wanga, S.Y., Yanga, T.H., Lina, L.T., Linb, C.J., Tsai, M.J., 2007: Properties of lowformaldehyde-emission particleboard made from recycled wood-waste chips sprayed with PMDI/PF resi. Building and Environment 42(7): 2472-2479.

Yong, J.W., Silikas, N., Zhang, Z.T. and Watts, D.C. (2011): Hygroscopic dimensional changes of self-adhering and new resin-matrix composites water sorption/desorption cycles. *Journal of Dental Materials* 27(3): 259 – 266

Forest Plant Barks used as Food in Ondo State, Nigeria

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ABSTRACT

In Ondo State Nigeria, forest plant barks are used as food condiments. They are also used for curative purposes. The plant barks are prepared using different traditional methods of food preparation. This work was carried out with the objectives of identifying forest plants whose barks are consumed as food condiments and also to examine the various methods of their preparation. The study zone was divided into three: Akure, Ore and Owo areas. An earlier reconnaissance survey had showed that forest plant barks were consumed in these zones. A total of 150 structured questionnaires were administered at 50 questionnaires per zone. Some of the questionnaires were administered in the major market centres within each zone while some were administered with the assistance of field staff of the State Department of Forestry so as to get to get local people living close to forest reserves in the State. The study showed a total of 30 forest plants whose barks were consumed for various purposes. The 30 plant species consist of 16 trees, 8 shrubs, 5 climbers and 1 herb species. They all belong to 20 different families with Leguminoceae (consisting of Ceasalpinioideae, Mimosoideae and Papilionioideae) represented by 6 species, followed by Annonaceae and Rubiaceae with 3 species each. Two other families are represented by 2 species each, while thirteen are represented by 1 species each. Others are represented each by a single species. Even though the barks are consumed as soup condiments, the reasons for including them in the diet are many. These include purgative, pregnancy management, cough control, malaria treatment, anti-hemorrhoid, cure of severe stomach pains and as condiment. Others are for asthma, low sperm count, concoction, black tongue, toothache, constipation, leucoplakia and stomach upset. It is recommended that there should be an urgent need for renewed interest in research and documentation of the uses of plant barks as food condiments. Forest conservation should also be promoted to avoid loss of forest biodiversity. This action should be to enhance the survival of human existence, and the consequent implications for human survival and socio economic stability of tropical nations.

Keywords: Condiment, plant barks, forest plants, forest food.

INTRODUCTION

Forests, especially in the developing world, provide a basis for the daily living of the people (Balick and Cox, 1997). Forest pants provides a wide variety of goods ranging from food, phytopharmaceuticals, herbal remedies, perfumes, cosmetics, colouring agents, detergents and varnishes (Lange and Schippmann, 1997). The vast numbers of food include nuts, fruits fibres, tubers, edible barks, and root. These provide energy, fibres, vitamins, protein, and protein, and essential mineral to the human diet. Plant barks are cheap sources of energy, carbohydrates and minerals which are essential for human growth and development. In severe famine plant bark such as that of Baobab, *Adansonia, digitata*, are consumed as food (Irvine, 1952). The fishermen from coastal East Africa cut the stem and bark of Cycads (Cycus *thuarsii*) into pieces and allow them to ferment for a week, it is then washed, sun dried and pounded into flour (Weiss, 1979). In *Premma mucronata* are ground into a find flour to make *Chepatis*, which is normally made with wheat or rice four (Food and Agricultural Organization, 1984).

The Sami people of northern Scandinavia historically uses the inner bark of the birch tree. To them, the birch tree (both *Betula pubescens* spp. and *B. pendula* spp.) is central to their way of life. They typically harvest the bark from trees felled for timber, firewood, waterproofing, or handicrafts, peeling it off in large sheets from the smooth trunks while still fresh. Once harvested, the reddish brown, almost cork-like phloem is separated from the outer bark and left to dry either in the sun, by a fire or wood stove, or in a dehydrator. It is then ground into flour and used to make bread and crackers. Birch flour does not contain the gluten proteins

typically required to give bread structure and cohesion, and for this reason it is rarely used alone in baking. More often it is mixed with wheat or rye flour to make the dough more cohesive, and to smooth its bitter taste. (Sigrithur & MacGuire, 2015).
The diversity of diet that the forest food provides is more likely to be nutritionally balanced diet, and one of the most common caused of dietary deficiencies and food insecurity appears to be the decreasing diversity of traditional diet (Gura, 1996) in Nigeria, even through some ethnic groups consume barks, it is obvious that the nutritional aspects of barks are hardly recognized. The objective of this work to identify and document forest plant barks that are used as foods in the rain forest zone of Ondo State, Nigeria. The bulk of Nigerian population is rural and this rural section depends much on forest products for their survival.
The contribution of forestry to household food security is often neglected, yet the forest has played this role for centuries. The lack of recognition of forestry in food security, and forest destruction has combined to rob the rural population of the usefulness of forest resources for its survival.

METHODOLOGY

Area of study

The study was conducted in Ondo State, Nigeria. This is one of the 36 States in the country. The State is made up of 18 Local Government Council Areas (Ngex), and covers a total land area of 20,959 km^2. The estimated population of the State in 2016 is 3,441,024 and places 18^{th} in population among the 36 States in Nigeria (information hood).
It is bounded in the north by Ekiti and Kogi State, Edo and Delta States in the east, in the west of Osun and Ogun States, and in the south, by the Atlantic Ocean. The primary occupation of the people is farming. Because of the location, the swamp forests border the ocean, and the rain forests inlands, the northern portion of the State is covered by derived savanna vegetation. For logistic reason, the study was restricted to three zones in the rain forest zone of the state, namely, Ore, Akure and Owo. These were more accessible than other areas especially the riverine towards the Atlantic Ocean.

Data Collection and Procedure

A simple random sampling was used to select farmers living close to forest reserves in the three zones selected. Fifty farmers were selected from each of the zones with the assistance of forestry Office of the State's Ministry of Agriculture and Natural Resources. Lists of farmers were first complied, and these were randomly sampled. It was not possible to get a complete list of farmers either because of remote locations in the forest or absence of the farmers at the time of reconnaissance. Males and females found in the surveyed areas were regarded as farmers and were thus interviewed. Pre-tested questionnaires were used to obtained information on plant barks used as food in the study area. Questions were also asked on the age, gender and educational status of the respondents. Methods of analysis were tabulation and descriptive statistics.

RESULTS AND DISCUSSION

Age of respondents

The age results showed that the use of plant barks cuts across different age groups. Plant bark consumption would appear to be an undying legacy in the study area.
As shown on the table, about 51% of the respondents fell between the age group of 21-40 years, while 38% or 57 respondents fell between 41-60 years. These figures should only be noted for the purpose of showing that forest plant bark consumption cut across different age groups. In future studies, multi-stage sampling should be employed.
The classification and age of the respondents are shown in Table 1.

Table 1: Age of Respondents

Age class (years)	Akure zone	Ore zone	Owo zone	Total	Percentage
21-30	16	20	18	54	36.00
31-40	10	8	5	23	15.33
41-50	13	10	14	37	24.67

51-60	5	8	7	20	13.33
Above 60	6	4	6	16	10.67
Total	50	50	50	150	100.00

Source: Field survey, 2013

The gender and marital status of the respondents

Table 2 showed the gender and marital status of the respondents. The males totaled 58 representing about 39%, while the females were 92(61%). The total number of married respondents was 105 that is 70%, the unmarried were 45 in number, that is 30%. It is women that are generally responsible for cooking at home and also for the sale of plant materials in the market places. Women are also actively involved in sourcing plant products from the forest. Any measure, therefore in the conservation of plant genetic resources should consider the role of women.

Table 2: Gender and Marital Status of the Respondents.

Marital status	Zone and number of respondents by gender								
	Akure		Ore		Owo		Total		Grand total
	Male	Female	Male	Female	Male	Female	Male	Female	
Married	12	26	13	19	16	19	41	64	105
Single	4	8	10	8	3	12	17	28	45
Total	16	34	23	27	19	31	58	92	105

Source: Field survey, 2013

Educational Background of Respondents

The results of the educational background of the respondents are presented in Table 3.

Table 3. Educational Background of Respondents

Educational background	Zone and number of respondent				
	Akure	Ore	Owo	Total	Percentage
No formal education	10	12	17	39	26.00
Primary school	13	16	17	46	30.67
Secondary school	22	20	13	55	36.67
Tertiary school	5	2	3	10	6.67
Total	50	50	50	150	100

Source: Field survey, 2013

Twenty six percent of the respondents had no formal education. A total of 111 respondents representing 74% had formal education. This is no surprise. Apart from farming, education is the most important occupation of the people of Ondo State. It could be deducted that education was no barrier to the consumption of forest plant barks in the state.

A total of 30 plant species were consumed by the respondents. These were made up of 16 tree species in 13 families, 8 shrub species in 6 families, 5 climbers from 5 families and 1 herb species from 1 family (Tables 4 and 5). Tree species constituted 53.3% of the total number of species, shrub 26.7%, climbers 16.7% and herbs 3.3%.
The plant barks are put into a total of 16 uses which are mainly medicinal. Twelve plant speices are used in the treatment of Malaria fever, 10 for heamorrhoids, 8 as soup condiments, 4 for stomach pain, 3 for constipation, and 2 as purgatives. One plant species is each used for the treatment of cough, asthma, toothache, worm expulsion, male impotence, black tongue (an indication of toxemia in the body) and leucoplakia. Also, a plant species is each used for pregnancy management, vitality, and aiding recovery from sickness.

These findings showed that the barks of some plant species are nutritionally important to the native people. These are sourced from the forest. Forests, therefore, are crucial to the nutritional survival of the people. In addition, there seems to be no difference between nutrition and medicine as shown by the result. Most of the barks are consumed as food but for the purposes of medicinal treatment. This is similar to the case of the indigenous peoples of Canada. There they collectively used over a thousand different plants for food (including inner barks of some trees), medicine, materials, and in cultural rituals and mythology (The Canadian Encyclopedia). Further studies are required to identify the efficacies of the barks, and therefore, for possible bio- prospecting.

Table 5. Plant Species and Forms by Families utilized by Respondents in the Study Areas.

S/N	Family	Herb	Shrub	Climber	Tree	Total
1.	Anacardiacea				1	1
2.	Ancistrocladaceae		1			1
3.	Annonacceae			1	1	3
4.	Aristolochiacceae			1		1
5.	Asclepiadaceae			1		1
6.	Euphorbiaceae		1		1	2
7.	Guttiferae				2	2
8.	Caesalpinioideae			1	2	3
9.	Mimosoideae				1	1
10.	Papilionoideae		1		1	2
11.	Menispermaceae		2			2
12.	Moraceae				1	1
13.	Nyctaginaceae	1				1
14.	Ochnaceae				1	1
15.	Olacaceae				1	1

16.	Rubiaceae		2		1	3
17.	Simaroubaceae				1	1
18.	Sterculiaceae				1	1
19.	Tiliaceae		1			1
20.	Vitateae					1
Total		1	8	5	16	30

The above shows a wide range of plant resources that are as sources of plant barks to the farmers.
Leguminosae: Caesalpinirideae
Mimosoideae
Papilionoideae

Table 4. Forest Plant Barks utilized for Food Condiments in the Forest Zones of Ondo State Nigeria.

S/N	Local name of plants	Scientific name	Family	Plant form	Part used	Uses	Method of use
1	Kasu	*Anacardium occidentale* Linn.	Anacardiaceae	Tree	Stem bark	Malaria	Mashed together with rook bark of *Morinda lucida*, stem bark of *Xylopia aethiopica*, add pepper, fish, palm oil, fish/meat and salt, cook as soup.
2	Lapawe	*Hexalobus crispiflorus A.* Rich	Annonaceae	Tree	Stem bark	Malaria	Mashed together with stem bark of *Chasmanthera dependens*, leaves of *Ocimun gratissimum*, add pepper, palm oil, fish meat, salt, cook as soup.
3	Eleruju	*Uvaria chamae* Engl. Diels	Annonaceae	Climber	Whole plant	Stomach pain Haemorrhoid.	Mashed and crushed together with stem bark of *Caesalpinia bonduc*, stem bark of *Nauclea latifolia*, add palm oil, fish/meat, cook and serve as soup. Crushed and mashed with stem bark of *Ancistrophyllum secundiflorum*, *piliostigma thoningii*, and add grinded ginger (*Zingiber officinale)*, pepper, onion, and seeds of *Piper guineensis*, add palm oil, fish/meat, cook and serve as soup.
4	Erinje	*Xylopia aethiopica* (Dunal) A. Rich.	Annonaceae	Tree	Stem bark	Haemorrhoid	Add bark of *Anacardium occidentale*, crush mixture, add palm oil, pepper, meat cook and serve as soup.

						Malaria	Could decoration of stem bark of *Anacardium occidentale* and *Morinda lucida*. Drink decoction.
5	Okuku	*Ancistrophyllum secundiflorum* (Mann & Wend) Hook. f.	Ancistrocladaceae	Shrub	Stem bark.	Haemorrhoid	Mash, with stem bark of *Pilostigma thonningii*, *Uvaria chamae*, add grinded pepper, ginger, onion, palm oil and fish cook and serve as soup.
6	Akogun	*Aristolochia ripens* Vahl	Aristolochiaceae	Climber	Stem bark	Malaria	Mashed together with stem bark of *Lophira alata*, add pepper, vegetable palm oil and other ingredients. Cook and serve as soup.
7	Isigun	*Tylophora glauca* Bullock	Ascepiadaceae	Climber	Stem bark	Soup condiment	Mash and grind, add locust beans *(Parkia biglobosa)*, onion, pepper, and fish/meat. Cook and serve as soup.
8	Ose	*Adansonia digitata*_Linn.	Euphorbiaceae	Tree	Stem bark	Soup condiment	Mash and grind and use as soup condiment.
9	Ira	*Bridelia ferruginea.* Benth.	Euphorbiaceae	Shrub/tree	Stem bark	Cure for black tongue.	Mash the stem bark of *Hannoa undulata*, add little quantity of palm oil, pepper and meat. Cook and serve as soup.
10	Orogbo	*Garcinia kola* Heckel	Guttiferae	Tree	Root bark	Asthma	Peel the bark, the peel is grinded into paste, paste is mixed with water and taken for asthma.
11	Elu	*Lonchocarpus cyanescens* Kunth	Papilionoideae	Shrub	Stem bark	Stomach pain.	Crush bark together with cotton seeds, add water, sieve the mixture, and add pepper, locust beans (*Parkia biglobosa)*, meat and palm oil to filtrate,

							cook and serve as soup.
12	Arunje	*Harungana madagascariensis* Lam.ex Poir	Guttiferae	Tree	Stem bark	Haemorrhoid	Peel the bark, peel is mashed together with the bark of *Grewia mollis.* Add pepper and ginger grind all together. The paste is used as soup condiment.
13	Sayo	*Caessalpinia bonduc* (Linn.) Roxb	Caesalpinioideae	Climber	Whole plant (with root)	Concoction (for vitality Constipation	Mash and grind, add pepper, palm oil onion, and meat cook and serve as soup. Crush and mash together with stem bark of *Uvaria chamae* and *Sarcocephalus laifolius.* Add desired ingredients such as melon, pepper, palm oil, meat/fish, cook and serve as soup.
14	Obo	*Erythrophleum suaveolens* (Guill. & Perr.) Brenan	Caesalpionioidea e	Tree	Stem bark	Severe stomach pain. Condiment	Mash together with bark of *Ficus sur*. Sun dry mixture. Used as powder in soup. Add melon if desired. Mash bark with bark of *Bridelia ferruginea* and *Hannoa undulata.* And ginger, and other ingredients. Cook and serve as soup. Mash bark. Add pepper, locust beans, palm oil, cook and drink as concoction.

						Concoction (for sickness)	
15	Abafe	*Piliostigma thonningii* (Schum.) Mine-Redhead.	Caesalpinioideae	Tree	Stem bark	Treatment of leucoplakia Haemorrhoid	Eat fresh bark as snack. Mash together with bark of *Ancistrophyllum secundiflorum*, and *Uvaria chamae*. Add pepper, ginger, palm oil and dry fish. Cook and serve as soup.
16	Agbolosun	*Pterocarpus osun* Craib	Papilionoideae	Tree	Stem bark	Malaria	Crush together with stem bark of *Morinda lucida*, *Bridelia ferruginea*, *Harungana madagascariensis*, and *Anacardium occidaentale*. Grind all together, add alligator pepper (*Aframomum melegueta)*, palm oil, fish and other desired ingredients. Cook and serve as soup. Same as 13 (i)

						Haemorrhoid	
17	Olorira	*Chasmanthera dependens* Hochst	Menispermaceae	Shrub	Stem bark	Malaria	Mash together with stem bark of *Hexalobus crispiflorus*, and leaves of *Ocimum gratissimum.* Add other desired ingredients. Cook and serve as soup.
18	Ajo	*Spehnocentrum jollyanum* Pierre	Menispermaceae	Shrub	Root bark	Purgative Stomach up-set	Mash and crush together with root bark of *Ficus sur*, *Bridelia ferruginea* and seeds of cotton, add water, sieve, add to filtrate locust beans, pepper and palm oil. Cook and serve as soup. Same as above.

						(constipation)	
19	Ibo	*Ficus sur* Forssk.	Moraceae	Tree	Stem bark	Malaria	Mash fresh bark and grind together with the bark of *Grewia molis* Juss. (Tiliaceae), bark of *Sphenocentrum jollyamum*, and cotton seeds, add locust beans, palm oil, and a small quantity of gin (local alcohol). Mixture is boiled and drink.
20	Etiponla	*Boerhavia diffusa* Mill.	Nyctaginaceae	Herb	Root bark	Haemorrhoid	Peel the root and mash, add ginger, alligator pepper, garlic, locust beans, small quantity of palm oil and pepper. Cook and take as soup.
21	Pahan	*Lophira alata* Banks ex Gaertn. f.	Ochnaceae	Tree	Stem bark	Malaria	Grind the dry bark with the bark of *Aristolochia ripens*, and necessary soup ingredients to give taste. Cook and take as soup.
22	Ifon	*Olax subscorpioidea* Oliv.	Olacaceae	Tree/shrub	Stem bark/whole stem.	Worm expulsion.	Cut stem into pieces soak in water and drink extract.
23	Oruwo	*Morinda lucida* Benth.	Rubiaceae	Tree	Root bark	Malaria	Crush and grind the bark with the bark of *Bridelia ferruginea*, *Harungana madagascariensis* and *Anacardium occidentale*. All alligator pepper, palm oil, (small quantity), and other necessary soup ingredients. Cook and take as soup. Mash root bark into paste and use paste to prepare soup.
24	Egbesi	*Sarcocephalus latifolius* (Sm.) Bruce	Rubiaceae	Shrub/tree	Stem bark	Condiment	Peel bark, mash and grind peel into past and use as soup condiment.

						Malaria Tooth ache	Crush and grind together with stem bark of *Lophira alata*. Use paste as soup condiment. Eat bark raw or in dry state as chewing stick.
25	Irugba	*Parkia biglobosa* (Jacq.) *R.* Br. ex G. Don.	Mimosoideae	Tree	Stem bark	Cough	Mash together with stem bark of *Bridelia ferruginea.* Add soup ingredients cook and serve as soup.
26	Jabijabi	*Psychotria latistipulata* Benth.	Rubiaceae	Shrub	Stem bark	Severe stomach pain	Bark is used as soup condiment to stop any kind of severe stomach pain, especially in women.
27	Oriji	*Quassia undulata* (Guill. Perr.) D. Dietr.	Simaroubaceae	Tree	Stem bark	a. Constipation	Mash and grind the bark with those of *Bridelia ferruginea* and *Erythrophleum suaveolense*, add ginger, onion and garlic, then add palm oil, meat and cook as soup. Mash and grind the bark, add melon and other necessary ingredients, cook as soup.

						b. Condiment	
28	Obi edun	*Cola millenii K. Schum.*	Sterculliceae	Tree	Bark	Pregnancy management	The bark is combined with other herbs to make concoction for pregnant women.
29	Oraigbo	*Grewia mollis* Juss.	Tiliaceae	Shrub	Bark	a.Haemorrhoid, Condiment b. Malaria	The bark is mashed with that of *Harungana madagascariensis*, then added are garlic, *Piper guineensis*, *Aframomum melegueta* and fish. This mixture is prepared as soup for haemorrhoid, and also as soup condiment. Grind the bark with that of *Ficus capensis*, local gin is added, the mixture is boiled and drunk. The bark is powdered along with alum, lime orange juice is added. The mixture is drunk.

						c.Haemorrhoid	
30	Ogbolo	*Cissus pulpurea* Lindl.	Ampelidaceae	Climber	Whole plant	Impotence in men	The stem is cut into pieces, heat on fire. The pieces are mashed, then locust beans and salt are added, and the whole mixture is boiled and eaten as draw soup.

CONCLUSION

From the study, it can be stated that plant species sourced in the forest play a significant role in the diet of the local people, especially in Ondo State. The destruction of forests would amount to loss of forest resource potentials with possible attendant threat to the survival of people who depend on the forests for part of their food provisions.

REFERENCES

Anna Sigrithur & Avery MacGuire, 2015. Tree Bark www.nordicfoodlab.org/blog/2015/11/24/tree-bark 9/21/2016

Balick, M. and Cox, P.A., 1997. Ethno botanical research and traditional health care in developing countries. **In:** Medicinal plants for forest conservation and health care. Non-Wood Forest Products, 11, FAO, Rome, pp12-23.

Food and Agricultural Organization of the United Nations (F.A.O), 1984. Food and Fruit-bearing Forest species. Examples from South East Asia. FAO Forestry paper N. 44:2, Rome.

Gura, S., 1986. A note on traditional food plants in East Africa. Their value for nutrition and Agriculture. Food and Nutrition 12 (1):18-26.

Information hood. Nigeria States Population Ranking List 2016.www.informationhood.com/nigeria-states-population-ranking/ Accessed 10/04/2016

Irvine, F., 1952. Supplementary and Emergency food plants of West Africa. *Economic Botany* 6 (1): 23-40.

Lange, D. and Schippmann, U., 1997. Trade survey of medicinal plants in Germany: A contribution to International plant species conservation. Bonn-Bad Godesberg, Germany.

Ngex. Ondo State, Nigeria. www.ngex.com/nigeria/places/states/ondo.htm 10/04/2016

The Canadian Encyclopedia. Indigenous Peoples: Uses of Plants.www.thecanadianencyclopedia.ca/en/article/plants-native-uses/

Ecology and Ethnobotany of *Okoubaka aubrevillei* Pellegr. & Norman: Viewpoint of Conservators and Forest Users in Edo State, Nigeria

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ABSTRACT

The rainforest in southern Nigeria is increasingly being ravaged by anthropogenic stressors, while most mono-generic and highly revered multi-utility tree species which have assortment of cultural and ethno-medicinal use values are increasingly being exterminated. Okoubaka aubrevillei Pellegr.& Norman, also called 'African Juju tree' is the only known hemi-parasitic forest tree, which – despite the danger posed by unsustainable exploitation – is conspicuously missing on the IUCN data base on endangered/threatened flora in Nigeria. The ecology and ethno-botany of O. aubrevillei were evaluated in five Local Government Areas in the rainforest region of Edo State using questionnaire and key informants' interview to elicit responses from participants – government employees (forestry personnel), vendors in five markets, and herbalists/users in 14 communities. The snowball sampling technique was used and respondents were contacted based on recommendations from primary participants (forestry personnel).Data were analyzed using descriptive statistics. Results revealed that O. aubrevillei is used for treating diverse ailments (50.8%) and fetish applications (49.2%). The bark is the most frequently used part (78.4%); and users obtain them mostly from market vendors (47.9%) or directly from the wild (41.3%). Respondents posited that O. aubrevillei currently on the verge of being exterminated through, habitat loss (48.1%) and harvest pressure (43%). While affirming that the species has declined significantly across its geographic range despite its mythical powers as an iconic and totemic tree, respondents recommended that close-knit empirical investigation was imperative to uncover its ecological idiosyncrasies in order to rescue or save it from extinction.

Keywords: Ethno-medicine, hemi-parasite, indicator species, mythical tree, non-pioneer

INTRODUCTIION

Okoubaka aubrevillei Pellegr. & Norman is the only hemi-parasitic tree found in the rainforest region of Nigeria. Its name is derived from the word: *'Oku baka'*, an Ayin Language in Cote d' voire, meaning 'death tree' (Lowe, 2012). It is a non-pioneer tropical tree usually found in closed cover of evergreen forest (Burkill, 1985), rocky hills (Dovi, 2013) or slopes, and mostly alone in areas where it is found (Borokini, 2015). *O. aubrevillei* is an important medicinal plant which has remained invaluable in the herbal drugs business. WHO (2001) defines medicinal plant as herbal preparations produced by subjecting plant materials to extraction, fractionation, purification, concentration or other physical or biological processes which may be produced for immediate consumption or as a basis for herbal products. Ethnobotany is concerned with the relationship between people and plants (Jones, 1941), including attitude of people towards them like naming, classification, uses, management and the values placed on them (Hamilton *et al*., 2003).

O. aubrevilllei currently faces serious anthropogenic threats in places where it is endemic in Nigeria (Borokini, 2015; Isikhuemen (2012). This is as a result of the high demand for its parts, particularly 'tree bark' by local people for diverse uses, e.g. treatment of various ailments (Isikhuemen and Iduozee, 2008), spiritual protection (Maundu *et al*., 2006; Myren, 2011), construction and firewood (Ladipo *et al*., 2008), and sacred and magical purposes (Marshall and Hawthorne, 2012). Despite the enormous value placed on the tree by local people, *O. aubrevillei* is neither on the national checklist of threatened flora nor on the International Union for the Conservation of Nature and Natural Resources (IUCN) data base (IUCN, 2004; Borokini, 2015). According to Osemeobo (2005, 2007) "there were less than 20 growing stands of *O. aubrevillei* in Nigeria"; however, Ihenyen *et al.* (2009, 2010, 2011) "hypothesized that a tree was found in every 0.08km^2."

The rainforest is located mainly in the Southern part of Nigeria, between Latitude 4^{o}and 9^{o} N (Ola-Adams and Iyamabo, 1977). It is seriously influenced by anthropogenic stressors such as loss of habitat occasioned by land degradation and pollution associated with oil and gas exploration, agricultural intensification, including slash and burn agricultural practices, intensive and uncontrolled logging, development of infrastructure and urbanization, etc (Isikhuemen, 2014). According to Isikhuemen (2012), these stressors have negatively influenced the lifestyle of rural and forest dependent poor – to the extent that they have to contend with diminishing levels of small forest incomes, as well as fluctuating values of products and poor harvest returns. The trend in the

decline of the rainforest ecosystem will ultimately lead to the disappearance of some mono-generic tree species most of which are yet to be characterized and largely unknown (Isikhuemen, 2014). Despite the rich potentials of *O aubrevillei* to shore up the nation's foreign exchange earnings, it is being harvested indiscriminately for timber as well as herbal enhancement in ethno-medicine. According to Szaro (1992), the best time to restore a species or an ecosystem is when it is still available or present (*cf.* Plate 1).



Plate 1: A healthy tree of *Okoubaka aubrevillei* Photo by E. E. John-Onyijen (2016)

Most studies conducted on *O. aubrevillei* by earlier scientists were largely reviews or generalizations based on make-believe reports from subjective investigations. This study – the first of a series of ongoing investigations – is intended to lay the necessary empirical foundation to clarify the current state of knowledge on the species population and its idiosyncrasy in relation to consociated species. The paper evaluates the ecology and ethno-botany of *O. aubrevillei* based on the perspectives of forestry personnel, vendors and users.

MATERIALS AND METHODS

Study Area

The study was carried out in the rainforest region of Edo State (Lat.05^{o} 44^{1}N & 7^{o} 34^{1}N and Long. 05^{o} 4^{1}E &06^{o}45^{1}E) (United Nations Development Programme, 2005). Edo State has a total land area of 19,707km^{2} and human population of 3,233,366. It has rainforest vegetation in the South, derived and guinea savanna vegetation types in central and north senatorial districts. The climate is characterized by wet and dry seasons; and has annual rainfall ranging from 2800mm to 1150mm. The relative humidity ranges between 90 percent and 70 percent while maximum and minimum temperatures average 35^{o}C and 22^{o}C, respectively.

Data Collection and Analysis

Data were collected in four purposively selected Local Government Areas (LGAs) – Orhionmwon, Ovia North East, Ovia South West and Uhunmwode – out of the seven LGAs which constitute the rainforest region of Edo State. We used two sets of semi-structured questionnaire and key informants' interview to elicit responses from participants; and the snowball sampling technique (Denzin and Lincoln, 2005) to select primary respondents (field staff of the Department of Forestry, Edo State Ministry of Environment and Public Utilities). Based on the former's recommendation, we reached out to selected traditional medicine practitioners in four LGAs as well as vendors in five selected markets in Oredo LGA. One hundred and ninety nine (199) copies of questionnaire were administered to participants in 14 communities and five markets; however, 135 were retrieved: 95 copies from users/forestry personnel and 40 from traditional medical practitioners/market vendors (Table 1). Data were subjected to simple descriptive statistical analysis after transformation using harmonic mean.

Table 1: Questionnaire and Key Informant Tools Used

Participant	Dept/LGA/Mkt.	Respondent	Tool	Administered	Retrieved
Field staff	Forestry Dept	Forestry Department	1,2	50	21
Herbalist/User	Orhionmwon	Ologbo-nugu	1,2	10	6
		Ugo	1,2	10	9
		Uguomokhua	1,2	10	6
Herbalist/User	Ovia N/E	Odighi	1,2	5	2
Herbalist/User	Ovia S/W	Iguobazuwa	1	7	5
		Iguoriakhi	1	8	6
		Ikoka	1	5	5
		Udo	1,2	10	6
Herbalist/User	Uhunmwode	Egba	1	6	3
		Ehor	1,2	10	8
		Igbogiri	1	5	2
		Igomoson	1,2	10	9
		Ugbiyaya	1	3	1
		Umuokpe	1,2	10	5
Vendors in Mkt	Oredo(Market)	Edaiken	1	4	4
		Ekiosa	1	5	5
		N/Benin market	1	7	7
		Oba market	1	5	5
		Oliha Market	1	4	4
Herbalist/User	OviaN/E	Odighi	1,2	4	1
Herbalist/User	Uhunmwode	Umuokpe	1,2	2	2
		Ugomoson	1,2	1	1
		Total		**199**	**135**

Source: Field study (2016) Mkt. = Market; 1 = questionnaire, 2 = key informants' interview

RESULTS

Ethno-medicinal Application/Uses of *Okoubaka aubrevillei*

A significant number of the respondents that cut across the different groups, namely, vendors in selected markets, herbal practitioners and users in different communities were unanimous in their submissions that *O. aubreville* is totemic and effectiveness for the treatment of diverse ailments and fetish cases (Table 2). However, a significant number of participants (29%) submitted that the bark was most frequently harvested; maintaining that it could be used solely or in combination with other plant parts to prepare concoctions or infusions (Figure 1).

Table 2: Uses of *Okoubaka aubrevillei*

Market	Uses in ethnomedicine		
	Treat ailment	**Totem**	**Total**
Edaiken	4	2	6
Ekiosa	2	4	6
New Benin	6	5	11
Oba	2	4	6
Oliha	2	4	6
Ologbo-nugu	5	4	9
Ugo	4	3	7
Odighi	1	1	2
Ikoka	1	-	1
Udo	1	-	1
Ogomoson	1	1	2
Umukpe	2	2	4
Total	**31**	**30**	**61**
Percent (%)	**50.8**	**49.2**	**100**

Source: Field Study, 2016

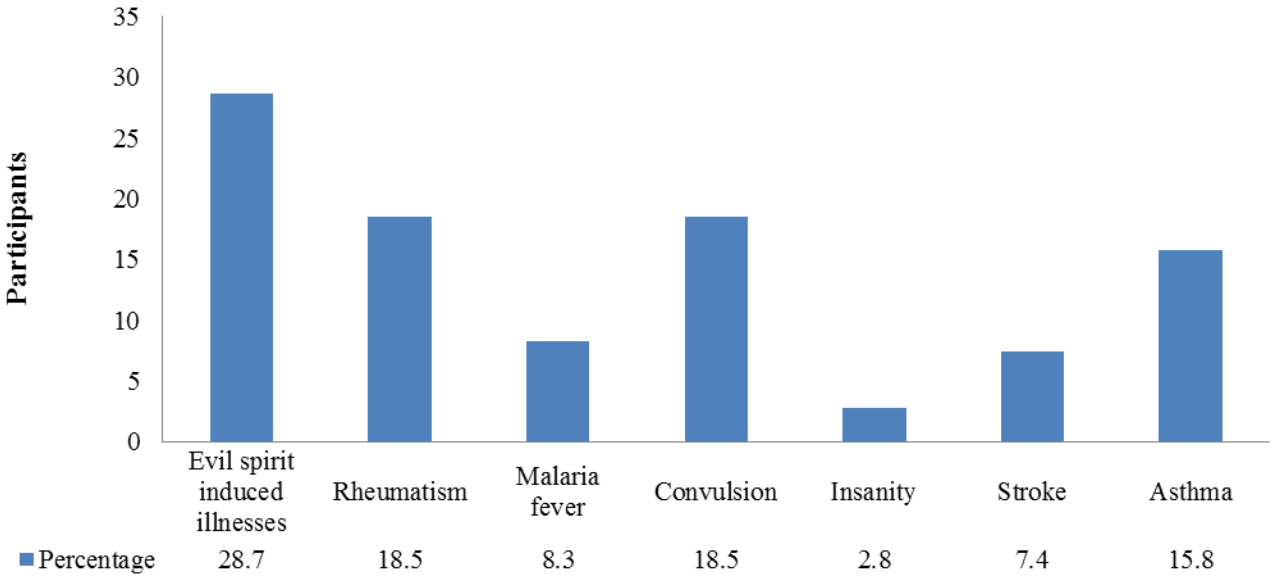


Figure 1: Ailments *Okoubaka aubrevillei* prevents and/or Cures

The respondents' opinions on the most frequently used parts of *O. aubrevillei* for the treatment of ailments and fetish application across stakeholder domain were diverse. While the participants in New Benin Market (Oredo LGA) claimed that the 'bark' was most favoured by users, respondents in Ugo and Ologbo-nugu (Orhionmwon LGA) contended that the bark, leaf and seed were all used (Figure 2).

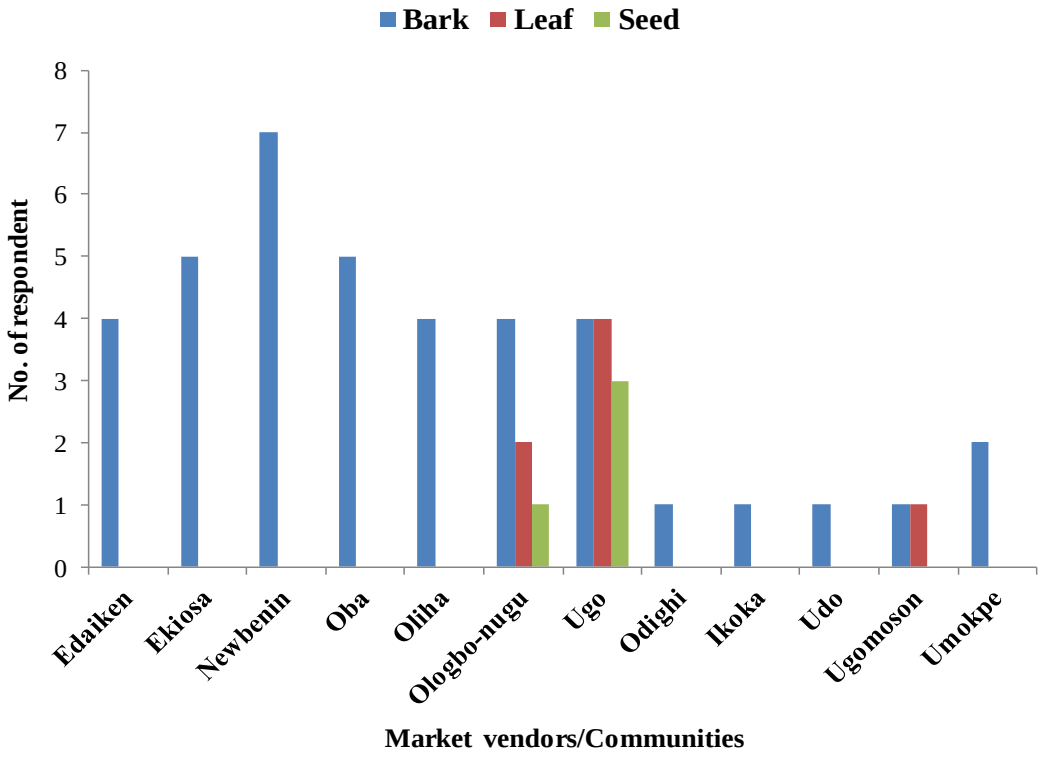


Figure 2: Most preferred parts of *Okoubaka aubrevillei* for ethnomedicinal application

Composition and Uses of *Okoubaka aubrevillei*

Table 3 shows the composition and different methods that herbal doctors and end users adopt in preparing herbal medications and supplement (e.g. infusion, decoction, etc.) for the treatment of ailments. The largest number of participants who provided insight on the diverse ways of preparing infusion or decoction from this highly revered hemi-parasitic tree was recorded in New Benin market followed by Edaiken, Ologbo-nugu and Ugo markets (Table 3).

Table 3: Extraction, preparation and application of *O. aubrevillei* parts

Market	Pound bark for bathing (Infusion)	Bathe with bark & leaves (Infusion)	Mix bark with native soap & *A. melegueta* (Infusion)	Burn roots and rub (Decoction)	Bathe with ground bark mixed with other plant parts (infusion)	Immerse leaves in water & bathe or rub (infusion)	Total
Edaiken	0	0	4	0	0	0	4
Ekiosa	0	1	0	0	0	0	1
New Benin	5	0	0	1	0	0	6
Oba	1	0	0	0	0	0	1
Ologbo-nugu	1	0	1	0	0	2	4
Ugo	0	0	1	0	2	1	4
Odighi	0	0	0	1	0	0	1
Ikoka	0	0	0	1	0	0	1
Udo	0	0	0	1	0	0	1
Ogomoson	0	0	1	0	0	0	1
Umukpe	0	0	2	0	0	0	2
Total	**7**	**1**	**9**	**4**	**2**	**3**	**26**
Percent (%)	**26.92**	**3.85**	**34.62**	**15.38**	**7.69**	**11.54**	**100**

Source: Field Survey, 2016

Conservation Policy and Current Status of the Population of *Okoubaka aubrevillei* in the Wild

The consensus among respondents (90%) on the extant forest policy and law in Edo State was that they both constitute a disincentive and serious drawback on the value systems and cultural affiliation of forest users whose livelihood depend on *O. aubrevillei* and other NTFPs in protected and off reserve (free) areas. The overall views of participants presented in a - 4Likert scale response options revealed that the population of *O. aubrevillei* in the wild has not only declined but very scarce (91%). A significant number of respondents (34%) comprising forestry personnel and Ologbo-nugu participants posited that *O. aubrevillei* was no longer common in the wild (Table 4).

Table 4: Present status of *O. aubrevillei* in the wild

Dept./L.G.A	Respondent	Common	Rare	Very scarce	Lost	Total
Forestry Department	Field staff	-	13	8	-	21
Orhionmwon	Ologbo-nugu	1	-	5	7	13
	Ugo	-	2	-	-	2
	Igomukhua	-	-	6	-	6
Ovia North East	Odighi	-	1	1	-	2
Ovia south west	Iguobazuwa	-	5	-	-	5
	Iguoriakhi	-	-	6	-	6
	Ikoka	-	1	4	-	5
	Udo	-	4	2	-	6
Uhunmwode	Egba	-	3	-	-	3
	Ehor	-	-	8	-	8
	Igbogiri	-	3	-	-	4
	Ugbiyaya	-	-	1	-	1
	Ugomoson	-	8	1	-	9
	Umokpe	-	-	5	-	5
Total		**1**	**40**	**47**	**7**	**95**
Percent (%)		**1.0**	**42.1**	**49.5**	**7.4**	**100.0**

Source: Field study (2016)

Majority of the respondents (77%) agreed that *O. aubrevillei* bark is the most frequently harvested. However, participants (76%) averred that when scarring is extensive and beyond elastic limits of instigating inherent repairs, the tree could be predisposed to physiological breakdown or irreparable damage, and ultimately might result in death (Figure3; Plate1).

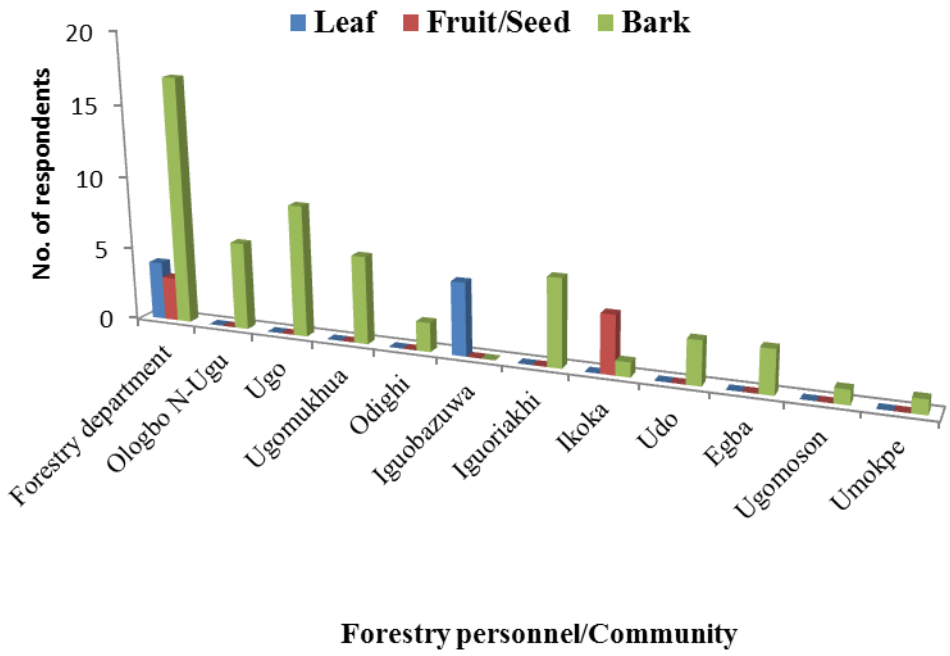


Figure 3: Tree part that could predispose *Okoubaka aubrevillei* to breakdown in physiology/death



Plate 1: A heavily scarred trunk of *Okoubaka aubrevillei* recorded in Orhionmwon LGA
Photo by: E. E. John-Oyijen (2016)

Anthropogenic Threats and Ecological Amplitude of *Okoubaka aubrevillei*

The synchronized results (using harmonic mean) of analysis of threat factors and the species ecology (including its hemi-parasitic influence on consociated species) in its range are presented in table 5. The impact of habitat pressure was highest (*ca.* 59%) among forestry field staff and users while harvest pressure recorded best among herbalists and market vendors. However, a greater percentage of the respondents (48%) affirmed that *O. aubrevillei* kills most trees that grow around it through the magical power it possesses. Although participants submitted that it is not all trees that *O. aubrevillei* kills, they stated that the listed trees are commonly found within 12m radius of *O. aubrevillei* they however contended that a large number or consociation of luxuriantly growing *Myrianthus aboreus* in the forest could serve as an indicate of the presence of the species in the hemi-parasite in the environ or locality (Table 5).

Table 5: Threats and Ecological Characteristics of *Okoubaka aubrevillei*

Variable	Forestry staff/users (n=95)	Herbalist & vendors (n=40)	Total
Threat factor	**98.9%**	**77.5%**	**92.6%**
Harvest pressure	47.9%	68.4%	43.0%
Habitat pressure	58.5%	52.6%	48.1%
Poor regeneration	10.6%	36.8%	12.6%
Forage by frugivores	2.1%	0.0%	1.5%
Irregular seed year	0.0%	5.3%	0.7%
Consociated species	**75.8%**	**35.0%**	**63.7%**
Myrianthus arboreus	90.2%	57.1%	84.7%
Musanga cercropoides	9.7%	7.1%	9.3%
Celtis spp.	0.0%	28.6%	4.6%
Milicia excels	0.0%	7.1%	1.2%

Source: Field Study (2016)

DISCUSSION

The most important characteristic of *Okoubaka aubrevillei* which makes it highly attractive in ethnomedicine, especially for use in the treatment of strange ailments that have defied orthodox medicine, are its peculiarities as an iconic hemi-parasitic tree. Several authors (Borokini (2015; Marshall and Hawthorne, 2012; Isikhuemen and Iduozee, 2008; EMEA, 2000) have alluded to the fact that *O. aubrevillei* is not only totemic, but widely used for treating diverse ailments, notably, malaria fever, rheumatism, convulsion, asthma. Ita and Effiong (2013) compiled 6 poly-herbal mixtures involving *O. aubrevillei* barks for treating malaria fever. It is also worshipped by some local people and communities in West Africa – owing to the mythical/magical powers ascribed to it. It is used for spiritual protection and for resuscitating failing health conditions attributed to the evil spirits (Maundu *et al*., 2006 and Myren, 2011). According to Oseomobo (2007), the bark *O. aubrevillei* is used for the treatment of insanity, while decoction of tree bark and seed is used for treatment of convulsion (van Andel *et al.*, 2012).

The results obtained in this study are in accord with Borokini's (2015) assertion that the bark and seed have high demand for ethno-medicinal application in Nigeria and elsewhere. The geographical and ecological zone where *O. aubrevillei* grows in Edo State, Nigeria is similar to that reported for Ghana and elsewhere (Burkill, 1985; Veenendaal *et al.* 1996). According to the authors, tree growth is optimal in closed cover evergreen forest as well as in open forest conditions. The greatest challenges faced by *O. aubrevillei* in all its range in Nigeria include, habitat loss as well as unregulated and unsustainable harvest, particularly the tree bark which can produce debilitating scars, resulting in cessation of physiological activities and most times, death. The participants' views on harvest pressure and declining population and/or rarity of the species in its range in Nigeria is in agreement with Isikhuemen (2012) and Isikhuemen and Iduozee (2008) who asserted that the current status of its seriously depleted population in the wild might not be unconnected with harvest pressure and fragmentation or loss of habitat.

Hardie (1963) had underscored the mythical powers that some cultures and rural communities ascribe to *O. aubrevillei*. According to Hardie, the Edo tradition in Nigeria forbids the use of machetes to obtain the tree bark; preferring the use of wooden batten instead. The views of the majority of respondents are in conformity with Hardie's contention that "anyone who desires to harvest any the bark of *O. aubrevillei* would first of all strip himself naked some distance away, runs and embrace the tree armed with habitual materials e.g. cowries, white chalk, piece of white cloth, etc, for appeasement. The participants claimed that pacification and incantation are made simultaneously while person needing the part remain nude condition, the person quickly strikes the tree trunk with the wooden batten, takes a peel and then runs back to quickly wear his clothes. The assumption is that in the event that *O. aubrevillei* got annoyed and went in pursuit of the visitor to retrieve its bark, it would hardly recognize the man having put on his clothes.

The results of the hemi-parasitic temperament and idiosyncrasy of *O. aubrevillei*, particularly as it affects killing of most trees except few specialized taxa that grow luxuriantly forming consociations are in harmony with Isikhuemen and Iduozee (2008);

Isikhuemen (2014, 2012); Hardie (1963). While chronicling his findings in a rainforest site in Nigeria, Hardie (1963) reported that "no tree was found 80feet (*ca*. 24.4m) of okoubaka tree, except for *Myrianthus arboreus, Musanga cecropoides* and woody vernonia.

CONCLUSION AND RECOMMENDATION

Conclusion

Okoubaka aubrevillei is the only tropical forest hemi-parasitic tree which is highly regarded and worshipped as a totem in some parts of Southern Nigeria. Its use in ethno-medicine for fetish reasons and for the treatment of diverse ailments is awesome. The bark, seed and leaves are the most frequently used parts. Despite its current ethnomedicinal values and the potentials for future use in orthodox medicine, the species is seriously threatened in all its range by uncontrolled exploitation, harvest pressure and local extinction.

Recommendation

O. aubrevillei is increasingly assuming greater relevance in the health care delivery system both at the local, national and regional levels. It is therefore recommended that concerted efforts be put in place to develop policies and legislation to support the conservation of the relic stands while encouraging rural communities and government agencies to support its rehabilitation in areas where the population is at or below its critical threshold of naturally regenerating itself.

REFERENCES

Borokini I. T. (2015).*Okuobaka aubrevillei* (Peleg& Norman). A synthesis of existing knowledge for research and conservation in west and central Africa. *Journal of biology and life science*, 6: 67-77

Burkill, H. M. (1985). The Useful Plants of West Tropical Africa, Vol. 1, Families A-D, Royal Botanical Gardens, Kew.960 pp.

Denzin, N. and Lincoln, Y. (2005).*The Sage handbook of qualitative research*. Sage, Thousand Oaks, California, USA.

Dovi, E. (2013). Comparative Studies on the In-Vitro Antioxidant and Antimicrobial Properties of Methanolic and Hydro-Ethanolic Plant Extracts from Five Medicinal Plant Parts of Ghana.M. Phil Thesis, Kwame Nkrumah University of Science and Technology, Ghana 112pp.

European Agency for the Evaluation of Medicinal Products (EMEA) (2000).Okoubakaaubrevillei.Summary Report.The European Agency for the Evaluation of Medicinal Products.Vertinary Medicine Unit, United Kingdom.EMEA/MRL/673/99-FINAL. http://www.ema.europa.eu/docs/en_GB/document_Library/Maximum_Residue_Limits_Report/2009/11/Wc500015212.pdf

Hamilton, A. C., Pei, S., Kessy, J., Khan, A. A., Lagos-Witte, S., and Shinwari, Z. K. (2003). The purposes and Teaching of Applied Ethnobotany. People and Plants Working Paper. WWF, Godalming, U. K. http://www.rbgkew.org.uk/peopleplants/wp/wp10/index.html

Hardie, A. D. K. (1963). *Okoubaka*- A Rare Juju Tree.*The Nig. Field, 27*(2), 70-72.

Ihenyen, J., Okoegwale, E. E., and Mensah J. K.(2009). Composition of Tree Species in Ehor Forest Reserve, Edo State, Nigeria.*Nat. Sci*. 7(8), 8-18

Ihenyen, J., Okoegwale, E. E., and Mensah J. K. (2010). Tree/ Shrub Species Diversity of Ehor Forest Reserve in Uhunmwonde Local Government Area of Edo State, Nigeria.*Researcher*. 2(2), 37-49.

Ihenyen, J.,Mensah J. K., W. O. Osunde, and E. Ogie-Odia(2011). Checklist of the Tree/Shrub Species of Edo State, Nigeria.*JApple.Env Biol. Sci*. 1(9), 276-282

International Union for Conservation of Nature and Natural Recourses (IUCN) (World Conservation Union).(2004). Red list of Threatened Species. IUCN, Gland, Switzerland. Available from http://www.iucn.org/themes/ssc/redlist.htm.

Isikhuemen, E. M. (2012). Resolving Institutional Impedement to Foster Conservation of Threatened and Under-Utilized Rainforest Flora in Southern Nigeria.UNU-INRA Seminar Series, UNU-INRA.United Nations University- Institute for National Resourses in Africa. Accra, Ghana.www.inra.unu.edu

Isikhuemen, E. M. (2014). Rainforest Degradation in southern Nigeria: Role of Forestry Institutions. UNU-INRA Working Paper 7.United Nations University- Institute for National Resources in Africa, UNU-INRA. Accra, Ghana. 41pp.

Isikhuemen, E. M. And Iduozee, O. F. (2008).Degraded Forests in Protected Landscapes: Prospects for Biodiversity Rehabilitation in Urhonigbe Forest Reserve, Edo State, Nigeria.*In*: Parrotta, J.A., A. Oteng-Yeboah, and J. Cobbinah (eds.).Traditional Forest-Related Knowledge and Sustainable Forest Management in Africa. IUFRO World Series, Volume 23.

Ita, P. B. and Effiong, E. E. (2013). Medicinal Plants Used in Traditional Medicine by Rural Communities in Cross River State, Nigeria. *J. Health, Med.Nurs*. 1. 23-29

Jones, V. 1941. The nature and scope of ethnobotany. *Chronica Botanica* 6, 219-221.

Ladipo, D. O., Adebisi, A. A., and Bosch, C. H. (2008).*Okoubaka aubrevillei* Pellegr. & Normand. In: Schmelzer, G.H. and A. Gurib-Fakim (Eds.). Prota 11(1): Medicinal plants 1. [CD-Rom].PROTA, Wageningen, Netherlands.

Lowe, J. (2012). Comment on the Research Note Igi-nla (Big tree). *The Nig. Field*, 77, 127-128.
Marshall, C. A., and Hawthorne, W. D. (2012). Important Plants of Northern Nimba County, Liberia: A Guide to Most Useful, Rare or Ecologically Important Species, with Mano Names and Uses. Oxford Forestry Institute, Oxford, England.460 pp.
Maundu, P., Kariuki, P., and Eyog-Matig, O. (2006).Threats to Medicinal Plant Species – an African Perspective. *In*: Miththapala, S. (ed.) Conserving Medicinal Species: Securing a Healthy Future. IUCN: Ecosystems and Livelihoods Group, Asia 184 pp.
Myren, B. (2011). Magic Plants in the South of Ghana. Report of Research Internship. Biology Leiden University, Belgium. 52pp.
Ola-Adams, B. A. and Iyamabo, D. E. (1977).Conservation of Natural Vegetation in Nigeria. *Environmental Conservation* 4(3) 217 – 226.
Osemeobo, G. J. (2005). Living on the Forests: Women and Household Security in Nigeria.*Small-scale For. Econ., Mgt. Policy*, *4*(3), 343-358.
Osemeobo, G. J. (2007). Who decides on access to genetic resources? Towards Implementation of the Convention on Biological Diversity in Nigeria. *Small-scale For. 6*. 93-109.
Szaro R. C (1992). Biodiversity and Biological Realities in getting to the Future through Silviculture Workshop Proceedings, Cedar City. May 6-9, 1991. General Technical Report INT -291. Inter mountain Resource. Station Forest Service. Ogden. UT. Pp5-6. Isis /9108.pdf
United Nations DevolopmentProgramme (UNDP) (2005). Edo State Economic Empowerment and Development strategy Report, June, 2005. 7p.
van Andel, T., Myren, B., Onselen, S. V. (2012). Ghana's herbal market. *J. Ethnopharm.*140. 368-78.
Veenendaal, E. M., Abebrese, I. K., Walsh, M. F., and Swaine, M. D. (1996). Root Hemi-parasitism in a West African Rainforest Tree *Okoubaka aubrevillei* (Santalaceae). *NewPhytol.*134, 487-493.
World Health Organization. (2001). Legal Status of Traditional Medicine and Complementary/ Alternative medicine: A world-wide review. WHO Publishing 1.

Survey on Honey Production System and Constraints in Bokkos Local Government Area of Plateau State, Nigeria

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ABSTRACT

The study was conducted in the seven district of Bokkos Local Government area of Plateau State, Nigeria. The aim of the study was to identify the honey production system and major beekeeping constraints in the study area. Structured questionnaire were distributed in the districts and villages across 68 bee keepers using stratified random sampling. The study used interviews and visual observation as methods in seeking answers to research questions. The data collected were analyzed using SPSS version 20 and descriptive statistics for the socio economic characteristics of respondents and beekeeping practices in the study area while Musa et al., (2006) rank index were employed to analyze the data on constraints. The result of the study revealed that the average amount of honey harvested /hive/year from traditional hive and the transitional hive was 8.82% and 4.41% respectively, with the traditional hive producing higher yield. Most of the bee keepers owned traditional hives (92.65%) with about 7.35% of bee keepers owning the transitional hives. The current practices and placement of bee colonies in the study area was mostly from parents ((98.53%- 1st) and then under caves and hanging on the forest (94.12%- 2nd). About 95.59% of the sampled beekeepers used plastic containers with 2.94% using earthen pot covers and 1.47% using gourd covers with no use of metal container. The major constraints to beekeeping activity in the study area were pest and predator (75%), pesticides and predators (23.53%), migration (1.47%). Damaging of hives and stealing of honey (thieves) were other constraints identified by beekeepers. In order to sustain the beekeeping activity of the study area, it is recommended that there should be affordable and appropriate extension service, supplying cheap beekeeping inputs, capacitating to beekeepers i.e. pests and predators control mechanism with adequate training on modern beekeeping practices.

Keywords: Honey, constraints, bee keeping, production, Bokkos

INTRODUCTION

Honey is a sweet natural food made by bees using water, pollen and nectar from flowers (Cantarelli *et al.,* 2008). The variety produced by honey bees (the Genus *Apis*) is the one most commonly referred to, as it is the type of honey collected by most beekeepers and consumed by people (Famuyide *et al*., 2014). Folayan and Bifarin (2013) reported that honey is produced by honey bee workers mainly from nectar of flower or honey dew on leaves. Nectar is reduced to honey containing predominantly carbohydrates with a very little protein, vitamins, minerals, enzymes, amino acids and as well as other several compounds like phenolic compound thought to function as antioxidants (Oyeleke *et al*., 2010, James *et al*., 2013). These chemical components are of great importance as they influence the keeping quality, granulation, texture, as well as the nutritional and medicinal efficacy of honey (Surendra, 2008). The market for beekeeping and honey production is huge. From cosmetics, medicine, confectioneries, and the pharmaceutical industries, to religious groups, the demand for organic honey and other bi-product is growing. The Apiculture specialists in Nigeria have tried in their capacity to replace oil as the major National foreign exchange earner, Nigeria's beekeeping and local honey production industry has not witnessed rapid growth. Rather, the industry has declined, with production in the number of beekeepers, apiaries and hives, which is reflected in the poor supply of honey, a healthy, natural sweetener.

Apiculture, the keeping and maintenance of bees for commercial reasons, often begins as a hobby that can later be expanded into a small business. Beekeeping for honey production is a profitable agricultural enterprise in all parts of the world including Nigeria. It is an important foreign exchange earner for countries that export honey and beeswax. Honey is a sweet, viscous liquid, dark golden in colour produced by bees from pollens and nectars and stored in honey combs in the hives. Unfortunately, beekeeping as a commercial venture is still largely unexplored in Nigeria, and the country meets domestic demand for honey mostly by importation from producer countries (Ja'afarfuro, 2007; Ayansola, 2009). There is a growing consumption of honey and other bee products because of its high values in maintaining good health and in treating wounds, infection of eyes and various diseases. With the current growth in domestic consumption of honey in Nigeria coupled with mechanized agriculture in every part of Nigeria (resulting in large crop acreages), the future of apiculture enterprise is very bright as the demand for honey

and pollinators is bound to increase, cost of beekeeping is low compared with other kinds of farming coupled with its high return on investment.

Apiculture is an industry that can help develop rural areas of Nigeria through increased farm income (Bradbear, 1991; Oduntan, 1999). It could also provide employment opportunities for majority of jobless individuals living in rural areas. There are however, major obstacles to apiculture development in Tropical countries mainly due to lack of capital as well as shortage of appropriate technical assistance for beekeepers. In spite of the favorable climatic and socio-economic environment, low-cost and sufficient availability of flowering plants and manpower, most developing countries have the following problems in common; lack of trained manpower and appropriate technical knowledge, limitation in resources, especially in the case of endemic diseases affecting bee colonies, lack of information on suitable internal/external markets, inappropriate processing technology for product diversification, lack of financial resources for sustainable apiculture development, among others (Dukku, 2001).

Though honey production raises the income of rural dwellers, appropriate harvesting techniques and marketing of it is yet to be fully utilized by households in the study area. Despite the favorable agro ecology for honey production and the number of bee colonies the country is endowed with, the level of honey production and productivity in the country remains low. However, like any other livestock sector, this sub Sector has been seriously devastated by complicated constraints. The prevailing production constraints in the beekeeping sub sector of the country would vary depending on the agro ecology of the areas where the activities is carried out (Ayalew, 1994; Edessa, 2002). Low productivity and quality of bee products are the major economic impediments for beekeepers (Nuru, 1999). Bee products are generally produced on a small scale in the country, this could be attributed to people's attitude of not really taking bee keeping as a form of vocation, which makes them to be naive of it numerous benefits, thus making the rate of expansion of apiculture industry to be relatively low compared to other fields of agriculture in Nigeria. This low expansion rate could be related to gross unawareness of the use and value of honey and other hive products, poor and ineffective collection, processing and preservation method (Cantarelli *et al*., 2014) as well as poor handling which results to product of inferior quality. Bokkos L.G.A found in Plateau State is one of the major areas in Nigeria where bee keeping is highly practiced but there has been little or no research documentation on the production system over the years.

MATERIALS AND METHOD

Study Area

The study was conducted in Bokkos Local Government of Plateau state, Nigeria Bokkos local government area is one of the 17 local government areas in Plateau State. It has a land mass of 3,053 square kilometers and a population of about 13,000 (1999 census). It is located about 77km away from Jos. The L.G.A. is inhibited by the following major ethnic (8) groups; Bokkos, Daffo, Sha, Manguna and Kulere found in Richa, Toff and Kamwai district and mushere which inhibit Mushere district. About 95% of the population of the area, are engaged in agriculture with the following farm produce, Stratified random sampling was used to select villages because it was discovered that not all villages in the study area had beekeepers. A total of seven (7) wards and six (6) villages under Bokkos L.G.A were selected where Beekeeping is highly practiced. These wards includes; Dashit, Gonde, Hottom, Hunti, Josho, Mandung, Mundat. The villages includes; Daffo, Sha, Karfa, Gonde, Manguna, Ambui.

Data Collection Procedure

Questionnaires were designed in line with the objective of the study. A total of 70 questionnaires were distributed among the beekeepers to obtain information. The questionnaires distributed were based on the target population of bee keepers in the study area. Interview schedule was used for illiterate farmers, while questionnaire was used for the literate farmers. Seventy (70) copies of questionnaire were distributed for data collection. Data for the study were obtained from a combination of primary and secondary sources but mainly through the former. The collected data were analyzed using statistical packages for social sciences (SPSS) software version 20. Ranking of beekeeping constraints was used to identify and prioritize the major beekeeping challenges to beekeeping development in the study area. The data were analyzed using simple descriptive statistics.

RESULTS

Table 1: Marital Status of Respondents

Educational Level	Freq	Percent
Cannot read and write	24	35.29
Can read	15	22.06
Primary	14	20.59
Secondary	15	22.06
Total	**68**	**100**

Table 2: Educational Level of Respondents

Marital Status	Freq	Percent
Single	0	0
Married	68	100
Divorce	0	0
Widow	0	0
Total	**68**	**100**

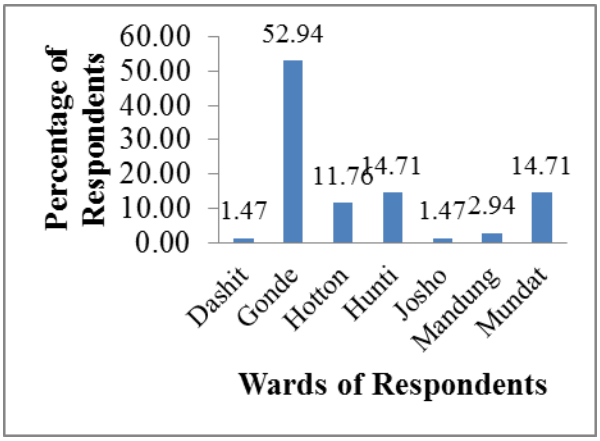


Figure 1: Socio economic of characteristics of Bee keepers in the study area

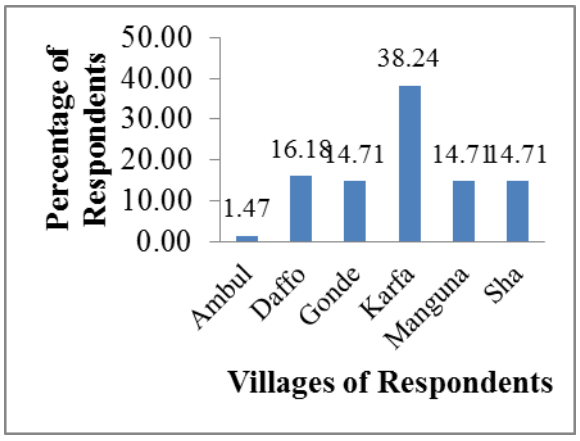
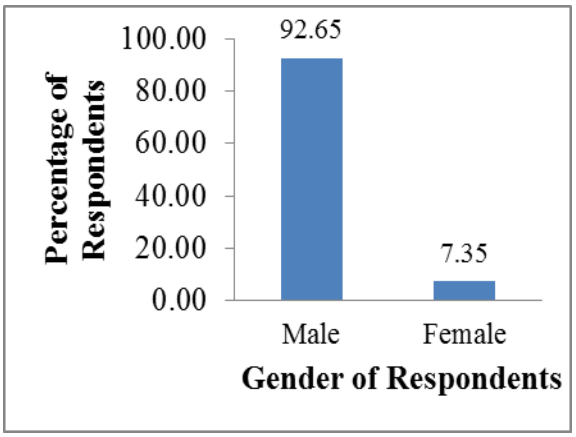


Figure 2: Villages of beekeepers (socio-economic characteristics)



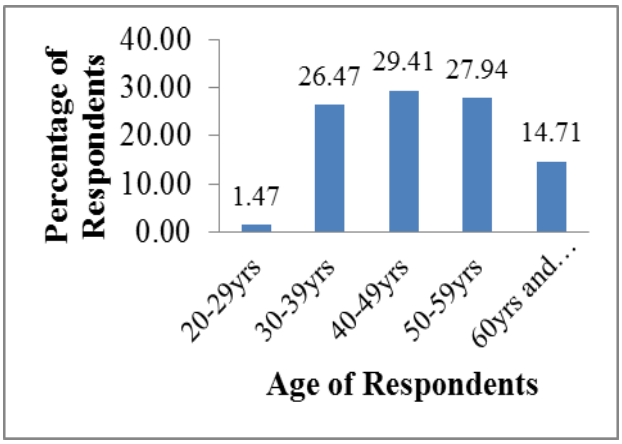


Figure 4: Age of beekeepers (socio-economic characteristics)

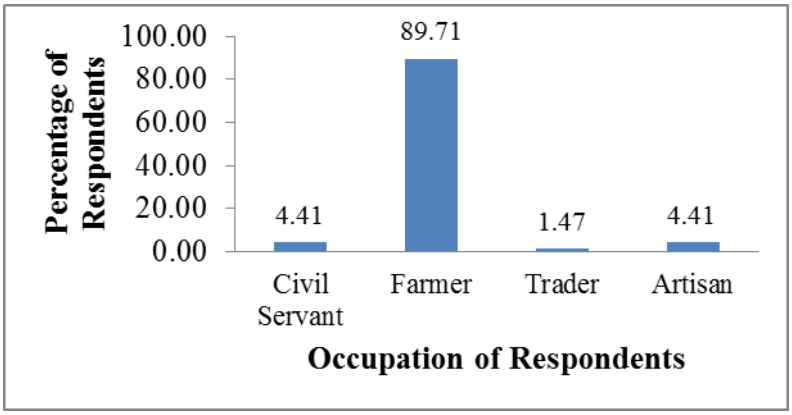


Figure 5: Occupation of beekeepers (socio-economic characteristics)

Table 3: Current Practices and Placement of Bee Colonies

Practices and Placement of Bee Colonies	Frequency	Percent	Ranking
From Parents	67	98.53	1st
Under caves and hanging on the forest	64	94.12	2nd
Backyard	3	4.41	3rd
Catching swarms	3	4.41	3rd
Placement of hives	2	2.94	4th
Backyard and under caves	2	2.94	4th
From parent and catching swarms	1	1.47	5th
Placement of hives	1	1.47	5th
Total	**143**	**210.29**	

Table 4: Honey Yield/Hive/Yr from Traditional Hive (Liters)

Yield/hive/yr	Freq	Percent
2.0	1	1.47
3.0	1	1.47
5.0	1	1.47
8.0	1	1.47
10.0	2	2.94
Total	**6**	**8.82**

Table 5: Honey Yield/Hive/Yr from Transitional Hive (Liters)

Yield/hive/yr	Freq	Percent
2	1	1.47
10	1	1.47
200	1	1.47
Total	**3**	**4.41**

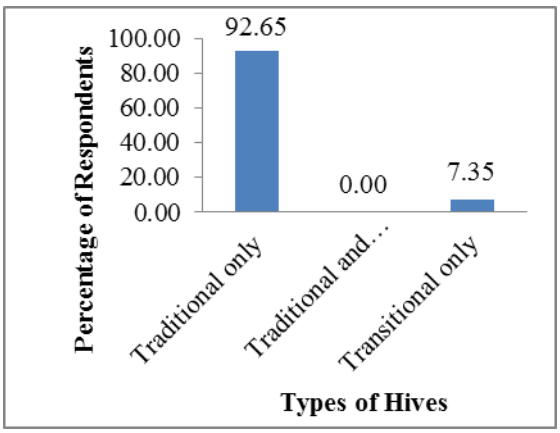


Figure 6: Types of bee hives used

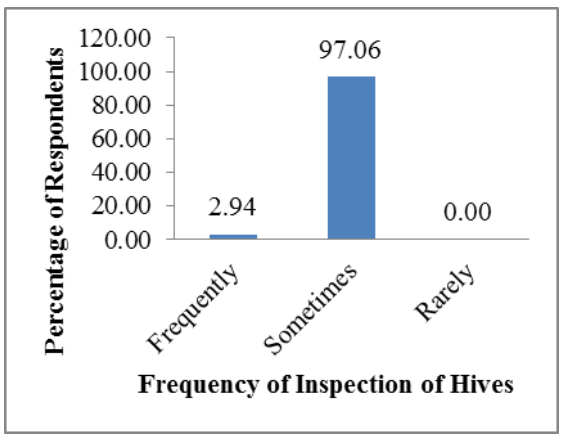


Figure 7: Frequency of Inspection of Bee by bee keepers

Table 6: Major Constraints of Bee Keeping

Constraints	Frequency	Percent
Shortage of bee forage	0	0.00
Shortage of water	0	0.00
Absconding	0	0.00
Pest and predators	51	75.00
Pesticides and predators	16	23.53
Death of Colony	0	0.00
Migration	1	1.47
Swarming	0	0.00
Storage facilities	0	0.00
Total	**68**	**100**

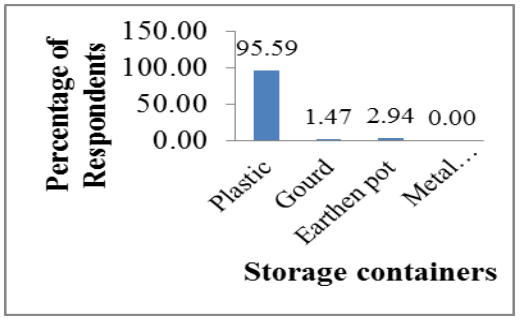


Figure 8: Types of storage containers

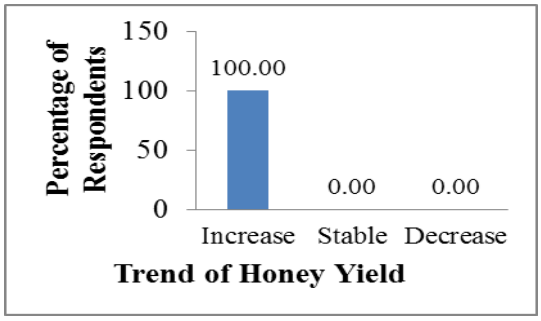


Figure 9: Trend of honey yield

DISCUSSION

The general characteristics associated with bee keeping of household respondents were distributed by sex, age, marital, occupational and educational status as presented in the results (Tables 1 and 2; charts 1 - 5). The majority of the respondents were males (92.65%); the females were about 7.35%. The sex of respondents was in the ratio of 9:1 for male and female, respectively. This agrees with Addis and Malede (2014) who reported that 97.5% of the interviewed bee keepers were males and only 2.5% were females. The very limited number of females' participation agrees with Tessega (2009) who states that only 1.7% were females. Similarly, Hartmann (2004) reported that traditionally beekeeping is men's job. Beekeeping activity in Bokkos Local Government Area is mostly practised with the traditional method of honey production with very few respondents using transitional bee hives. The transitional hives are hanging on tall and big tree branches. Females cannot climb up such big trees and as a result females are not encouraged to participate in beekeeping activities.

The age categories of respondents within the age of range of 40-49 had the highest percentage of 29.41% (Figure 4). This implies that people practising bee keeping in the study area within the age range of 40-49 had the highest population of bee keepers practising apiculture in the study area. This result showed that the people in the most productive age were actively engaged in beekeeping activities. The results agree with Chala *et al.* (2013) who reported that a mean age of the respondents was 40-47 years. Of the total bee keepers interviewed, 100% were married (Table 1) with none being single, widowed or divorced. This agrees with Tessega (2009) who stated that high percentages of the respondents were married. The educational level of the respondents of which those who cannot read and write had the highest percentage was 35.29%, followed by those who can read and those that have ascertained secondary school education level with both 22.06% (Table 2). Gichora (2003) noted that for more advanced bee keeping, one should have a good grasp of bee biology and behavior for better colony management. Moreover, for illiterate people, there is need for intensive training of bee keepers. The result

showed that Gonde wards and Karfa village had the highest number of persons engaged in apiculture (52.49% and 38.24%; Figure 1 and 2, respectively) with a high population of respondents being farmers (89.71%) in the study area (Figure 5).

More respondents got their colonies from parent (98.53%) and then under caves and hanging on the forest (94.12%) Table3. This does not agree with Addis and Malede (2014) who noted that 49.2% of the bee keepers started by catching swarms. Tesfaye and Tesfaye (2007) reported that about 70% of respondents got their bee colonies by trapping swarms. Most of the bee keepers owned traditional hives (92.65%) with about 7.35% of bee keepers owning the transitional hives (Figure 6). This indicates that the adoption rate of improved technology is very low. This might be because of the cost involved in the construction and purchase of transitional hives, lack of training on some important bee keeping practices and lack of harvesting and processing equipment. Similarly, Mahari (2007) reported that modern bee keeping productions require more expensive establishment cost, accessories and skilled training although, mostly yields better quality and quantity honey. Mostly, the bee keepers cannot read and write; hence they do not keep accurate records of honey production annually. But a few respondents agreed that the traditional hives which they mostly used produce more honey than the transitional hives. The highest production of honey recorded was 10 liters honey yield/hive/yr for the transitional hives while it was 200 liters honey yield/hive/yr for the traditional hives; with the average amount of honey harvested /hive/year from traditional hive for the transitional hive was 8.82% and 4.41%, respectively (Table 4 and 5). This does not agree with the report by Addis and Maleade (2014) and Chala *et al.* (2013) that stated that average honey yield per year/ colony was 7.20, 14.70, 23.38 liters for traditional, transitional and moveable hives, respectively.. The result indicated that though the studied area has shown an increase of 100% honey (figure 9) but it is below the line of productivity that the bee keeping industry can perform in Africa (Tessega, 2009). Poor honey yield production might be due to lack of using improved modern bee hives, poor training and technical know-how, pest and predators, pesticides and herbicide application, lack of water and poor management.

As reported by the sampled respondents, 95.59% of the sampled bee keepers used plastic containers with 2.94% using earthen pot covers and 1.47% using gourd covers, there was no use of metal container (Figure 8). Rivera *et al.* (2007) reported that most of the farmers store honey in clay pots until consumption or sale. Farmers use traditional containers which are technically not appropriate storage facilities as they result in quick crystallization, fermentation of honey and changing of general appearance and taste (Tesfaye and Tesfaye, 2007).

Nigeria has immense natural resource for beekeeping activity. However, like any other livestock, this sub sector has been ceased by complicated constraints. The prevailing production constraints in the beekeeping sub sector of the country would vary depending on the agro ecology of the areas where the activities are carried out (Ayalew, 1994; Edessa, 2002). The interviewed beekeepers mentioned that the major beekeeping constraints in the district are pest and predator (75%); pesticides and predators (23.53%) ; and migration (1.47%). This result agrees with report of Kerealem *et al*. (2009) 'shortage of bee forage', 'threat of pesticide, 'honeybee pest and predators', poor infrastructure development, 'shortage of bee equipment which were reported as the major beekeeping constraints. It also agrees with Yirga *et al.* (2012) that bee pests and predators, migration and shortage of bee forage were the major constraints affecting the honey sub sector. Pests and predators cause a serious devastating damage on honey bee colonies within short period of time and even overnight. The interviewed beekeepers stated the major bee pests and predators in the district were wax moth; spider; ants; bee-eater birds; honey badger; and beetles. This result agrees with the report of Kerealem (2005) 'ants, honey badger, bee-eater birds, wax moth, spider and beetles' were the most harmful pests and predators in order to decreasing importance of beekeeping. Similarly, many researchers found that ants attack is the most serious problem in beekeeping sector (Edessa, 2005; Desalegn, 2007). The result was also supported by study of Gidey *et al.* (2012) which reported that bee pests, predators and absconding are major constraints affecting honey sub-sector in Northern Ethiopia.

Since the people of Bokkos Local Government are mostly recognised for high potato production, maize and other vegetable crops. They use chemical spray such as pesticide and herbicide for pesticides and weed control without considering the damage on the bee colonies. The interviewed farmers stated that a number of bee colonies either die or abscond from their hives due to extensive use of agro-chemical in the study area. The chemical spray used by farmers is also affecting bee forage like herbs and shrubs which is used as sources of food or bee forage and nectar source. The use of pesticides that kill bees and herbicides are not toxic to bee colonies but destroy many plants that are valuable to bees as sources of pollen and nectar (Kerealem *et al*., 2009). Shortage of bee forage could be attributed to the high threat of deforestation in the study area as most beekeepers stated that trees are constantly felled for timber making, construction, fire wood and expansion of agricultural lands. These cause shortage of bee forage especially during the dry season. Most beekeepers of Bokkos L.G.A. have been shifting their bee colonies from their area to other area especially during the dry season as observed by the bee keepers in search of bee forage. The elimination of good nectar and pollen producing tree species in many areas make it difficult to maintain bee colonies without feeding (Kerealem, 2005). Other constraints identified by bee keepers included damaging of hives and stealing of hives by thieves. Folayan and Bifarin (2013) concluded that honey producers were highly constrained by high cost of establishment of hives and lack of fund. Beekeeping sector is dependent on healthy flora and a healthy environment. Most countries in recent years including Nigeria have seen environmental changes in terms of erratic rain fall patterns and deforestation. If these problems persist, the beekeeping sector could be affected (Oxfam, 2011).

CONCLUSION AND RECOMMENDATION

Honey production is a powerful way of tackling poverty at the grassroots level. It could be a useful avenue for improving rural economy. Beekeeping should be considered as a great source of employment creation for the rural people to reduce poverty. It also serves as an avenue for economic empowerment, ensuring household food security and poverty reduction. The result obtained showed that most of people in Bokkos L.G.A are farmers, males, married, within the age range of 40-49 and cannot read and write. The most widely used type of bee keeping is the traditional hive which was observed to produce more honey. Most colonies obtained by bee keepers were from parents and hanging in the forest. Honey was mostly stored in plastic containers and colonies were sometimes inspected. The most important constraints to honey production in the study area were pest and predator; pesticides and predators; and migration. The study revealed that the production of honey in the study area is governed by many factors which include high cost of modern bee equipment and accessories; low quality of honey products; lack of training on modern bee keeping practices; and poor infrastructure development.

There is need for further study on the characterization of honey bees in the area, identification of pests, predators and diseases that affect bee keeping. Government should provide credit facilities at a low interest rate to beekeepers in order to boast honey production.

REFERENCES

Addis, A., Malede B. (2004). Chemical analysis of honey and major honey challenges in and around Gondar, Ethiopia. *Aca. J. Nut* 3 (1)

Adebolu, T. T. (2005). Effect of natural honey on local isolates of diarrhea-causing bacteria in southwestern Nigeria. *African Journal of Biotechnology*, 4(10), 1172-1174.

Afar-Furo, M.R. (2007). Appraising the perception of farming communities towards adoption of apiculture as a viable source of income in Adamawa, Nigeria. *Apiacta*, 42: 1– 15

Al-Waili, N.S. & Boni, N.S. (2003). Natural honey lowers plasma prostaglandin concentrations in normal individuals. *J. Med. Food* 6(2):129-33

Alvarez-Suarez, J. M., Tulipani, S., Bertoli, S. R.E. & Battino, M. (2010). Contribution of honey in nutrition and human health: a review. *Mediterranean Journal of Nutrition and Metabolism*, 3, 15-23.

Badawy O. F. H., Shafii S. S. A., Tharwatt E. E. & Kamal A. M. (2004) Antibacterial activity of been honey and is therapeutic usefulness against Escherichia coli 0157; H7 and Salmonella Typhimurium infection. Rev. Sci. Technol Int., Epiz, 23: 10111-10122.

Bradbear, N. (1991). Banjul Bee Declaration. In: Proceedings the First West African Bee Research Seminar (Ed.) Gambia: Bakau, pp. 80-82.

Cantarelli, M. A., Pellerano, R. G., Marchevsky, E. J. & Camina, J. M. (2008). Quality of honey from Argentina: study of chemical composition and trace elements. *The Journal of the Argentine Chemical Society*, 96: 33–41.

Chala, K.., Taye, T. & Kebede, D. (2013). Production and marketing system in Gomma District, South Western Ethiopia, *G.J.Bus.Mana.Stu* 3 (3): 99-107

Famuyide, O.O., Adebayo, O., Owese, T., Azeez, F.A., Arabomen, O., Olugbire, O.O & Ojo, D (2014).Economic Contributions of Honey Production as a Means of Livelihood Strategy in Oyo State. *International Journal of Science and Technology*. 3 (1), 7 – 11.

Folayan, J. A. & Bifarin, J. O (2013). Profitability analysis of honey production in Edo North Local Govt of Area of Edo State, Nigeria. *Journal of Agricultural Economics and Development*, 2(2), 60-64.

Gounari, S. (2006). "Studies on the phenology of Marchalina hellenica (gen.) (Hemiptera: coccoidea, margarodidae) in relation to honeydew flow". *Journal of apicultural research.* 45 (1): 8–12.

James, O. O, Mesubi, M. A., Usman, L. A., Yeye, S. O. & Ajanaku, K. O. (2009). Physical characteristics of some honey samples from North-Central Nigeria. *International Journal of Physical Sciences*, 4: 464 -470.

Musa, L. A., Peters, K.J. & Ahmed, M. A (2006): On farm characterization of Butana and Kenana cattle breed production systems in Sudan. *Livestock research for rural development* 18 (12).

Oyeleke, S. B., Dauda, B. E. N., Jimoh, T. & Musa, S. O (2010). Nutritional Analysis and Antibacterial Effect of Honey on Bacterial Wound Pathogens, *Journal of Applied Sciences Research*, 6(11), 1561-1565.

Rozaini, M.Z., Zuki, M. Noordi, Y. Norimah & Haki, A.N. (2004). The effects of different types of honey on tensile strength evaluation of burn wound tissue healing. *Int. J. Applied Res. Vet. Med.*, 2: 290-296.

Subramanian, R., Hebbar, H. U. & Rastogi, N. K. (2007). "Processing of Honey: A Review". *International Journal of Food Properties.* 10: 127–143.

Tesfaye, K. & Tesfaye, L. (2007). Study of honey production system in Adami Tulu Jido Kombolcha district in mid rift valley of Ethiopia. *Livestock Research for Rural Development 1*9 (11) 2007.

Wilkins, A.L. & Lu, Y. (1995). "Extractives from New Zealand Honeys. 5. Aliphatic Dicarboxylic Acids in New Zealand Rewarewa Honey". *J. Agric. Food Chem. 43 (12): 3021*

Intra-Tree Variations of the Dimensional Stability along the Orthotropic Directions of the Wood of *Borassus aethiopum* Mart. in Different Ecological Zones in Nigeria

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ABSTRACT

Suitability of wood for end uses has been linked with its Tangential and Radial shrinkage, this research work therefore assess the dimensional stability of the wood of Borassus aethiopum in Nigeria. Five B. aethiopum trees each from Sudan, Guinea and Derived savanna zones in Nigeria were sampled at the base (10%), middle (50%) and top (90%) of the merchantable length and across the bole from bark to bark. Data were analysed using descriptive statistics and ANOVA. The mean value of Radial Shrinkage was 3.24±0.52% which ranges from 3.81±0.37%, 3.33±0.08% and 2.57±0.25% at the top, middle and base respectively. The mean values across the bole ranges between 4.18% to 1.32% at the base, 5.11±0.11% to 1.48±0.17% at the middle and 4.69±0.41% to 2.93±0.11% at the top. Tangential shrinkage was 3.71±0.14% with a range value of 2.99±0.37%, 3.67±0.07% and 4.44±0.45% at the base, middle and top respectively. Across the bole, it ranges from1.42±0.07% to 4.79±0.89% at the base, 1.98±0.19% to 5.47±0.19% at the middle and 3.18±0.07% to 5.94±1.02% at the top from the back to the centre. The mean value recorded for volumetric shrinkage was 6.94±1.10%, ranging between 5.56±0.58% at the base and 7.01±0.10% at the middle and 8.26±1.90% at the top, the values across the bole range between 2.74±0.09% to 8.75±0.05 % at the base, 3.46±0.30% to 10.44±0.07% at the middle and 6.11±0.17% to 10.64±1.42% at the top. Tangential shrinkage and radial shrinkage are not significantly different from each other unlike in dicot that tangential shrinkage is always twice radial shrinkage. Volumetric shrinkage varied consistently and significantly both along the tree height and from inner wood to peripheral. It could be inferred that B. aethiopum wood is relatively stable

Keywords: *Shrinkage, anisotropic, tangential, Radial and Volumetric*

INTRODUCTION

Wood normally shrinks as it dries and swells as it absorbs moisture. These changes in wood dimensions are of importance to anyone who uses wood, whether for tanks or toys, shoe lasts or ships, because wood readily takes on or gives off moisture, even from the atmosphere. Successful use of wood for exacting purposes under wide variations in atmospheric humidity shows that the problems arising from the shrinking and swelling of wood can be surmounted. When wood looses moisture below Fibre saturation point (FSP), it shrinks and swells when water is absorbed. Fibre saturation point (FSP) is a theoretical state where wood cavities are empty and the cell walls are saturated with water (Desch, 1988). The percentage change in wood dimension as a result of moisture loss is termed shrinkage (Dinwoodie, 1989). Due to the formation of successive growth rings in trees and the presence of tissues that are longitudinally or transversely oriented, wood exhibits directional anisotropy. (Evans, 1991) The observed changes in wood dimension as a result of shrinkage are unequal along the three structural directions. This behaviour of wood has been documented widely by various authors (Panshin and de Zeeuw, 1980; Dinwoodie, 1981; Lausberg *et al.*, 1995 and Ogunsanwo, 2000). However, Panshin and de Zeeuw, (1980), noted that the geometric disposition of cells along the principal directions is mainly responsible for this observation.It is well known that wood is an anisotropic material which presents differential dimensional changes in different structural directions. The change in dimensions as a consequence of changes in the moisture content of wood is of great practical importance in seasoning which has a direct effect on the manufacture of furniture and joinery (Usta and Guray, 2000). Wood swells when it comes in contact with water, therefore it is obvious that the wood absorbs water and thus increases in size to incorporate the water. This means that if a dry piece of woodwork is unprotected and comes into contact with water, its dimensions change and the piece of wood might not work as designed, that is, a door frame made from wood gets

wet which causes swell and stops the door fitting. Wood also shrinks when dried which can cause similar problems. Since shrinking of wood can cause so many problems and wood is anisotropic in nature. It is therefore, important to determine the shrinkage regime of lignocelullosic material along the orthotropic axis to reduce the associated problems.

This paper, therefore, assessed the shrinkage regime of *Borassus aethiopum* in the tangential and radial directions along the height and across the bole of the species because the greatest dimensional shrinkage occur along the tangential plane; shrinkage along the radial plane is considered less while the longitudinal shrinkage has been widely reported to be the least and it ranges from 0.1 to 0.3% (Desch, 1988; Dinwoodie, 1989).

MATERIALS AND METHODS

Five (5) trees were felled at each of the sites (Derived savannah from South-western Nigeria, Guinea savannah and Sudan savannah) especially where they are numerous. In order to ensure minimal influence of age, lack of management and other variables, trees initiating swollen top with uniformly close diameter were chosen. Because literature shows that before *B. aethiopum* can have swollen top, it must have attained the age of 25 years (Sanon and Sacande, 2007). Bolts of 50cm long were cut from each sample trees at the base (10%), at the middle (50%) and at the top (90%) of the merchantable length resulting in fifteen (15) bolts in each of the ecological zone.

The bolts were then brought to Department of Forest Products Development and Utilization, Forestry Research Institute of Nigeria, Ibadan Wood Workshop for further conversion to test samples. Selection of representative samples for test was carried out from the central planks obtained from all the bolts to give 45 planks from where test samples for all the experiment were obtained, 15 for each of the ecological zone. The central planks were further sectioned into 6 (six) portions from bark to bark.

Determination of Percentage Shrinkage

Test specimens of 20mm x 20mm x 40mm were prepared for this test; they were properly aligned and denoted 'T' and 'R' for Tangential and Radial planes respectively. They were soaked in water for 48 hrs in order to get them conditioned to moisture above Fibre Saturation Point (FSP). Specimens were removed one after the other; their dimensions in wet condition were taken to the nearest millimetre. Percentage shrinkages along the two planes were measured after specimens had been oven-dried as:

$$S = \frac{D_S - D_O}{D_S} X100 \quad \text{.....(1)}$$

Where: S = shrinkage %

D_S = dimension at saturated condition

D_O = dimension of oven dry condition

$$VS = S_R + S_T \quad \text{.....} \quad (2)$$

Where: VS = Volumetric shrinkage

S_R = Radial shrinkage

S_T = Tangential shrinkage

This is in accordance with approximations done by Dinwoodie, (1989).

RESULTS AND DISCUSSION

Radial shrinkage (RS)

The mean value of RS was 3.24±0.52% which ranges from 3.81±0.37%, 3.33±0.08% and 2.57±0.25% at the top, middle and base respectively (Table 1). It increased from the bark to the centre and later decreased towards the bark again, generally, RS increased towards the centre. This is in line with Akira, (1978), who observed 3.60% for the species from Gold Coast (Ghana), Guinea, Sudan and Kenya. Chudnoff, (1976). Poku, *et al.*, (2001), obtained a mean value of 2.51% for *Alstonia boonei*, 4.01% for *Petersantthus macrocarpus* and 2.23% for *Ricinodendron hendelotti* being lesser-used hardwood species from Ghana. Ogunsanwo and Ojo, (2011), observed 3.66% for *B. aethiopum*. The mean values across the bole ranges between 4.18% to 1.32% at the base, 5.11±0.11% to 1.48±0.17% at the middle and 4.69±0.41% to 2.93±0.11% at the top. Generally, consistent pattern of variation was observed across the bole from bark to bark (Fig. 1). Among the three ecological zones, the highest mean of radial shrinkage was observed in Derived savannah followed by Sudan savannah and Guinea savannah with mean value of 3.49±0.98, 3.20±0.67 and 3.02±0.55, respectively (Table 1). Radial shrinkage decreased gradually from the pith to the bark of dicotyledon, though reversal of the trend was observed by Ogunsanwo, (2000), in his work on obeche. This may be linked with the extent of cell wall development as dictated by age. Radial Shrinkage was also noted not lower than the tangential shrinkage. This is in agreement with the findings of Akira, (1978), who observed the same trend in the species from Gold Coast (Ghana), Guinea, Sudan and Kenya and it in agreement with statement made by Arancon, (1997), on coconut wood that "Unlike conventional wood where tangential shrinkage is almost twice the radial shrinkage, the tangential and radial shrinkage of cocowood are not significantly different". Ogunsanwo,(2000), in his work on *Triplochiton scleroxylon* and Choong, *et al*, (1989). Poku, *et al*, (2001), reported significant difference between radial and tangential shrinkage on lesser-used hardwood species from Ghana. Lausberg, *et al*, (1985), reported that this could have been caused by the presence of ray cells on the radial plane with their horizontally aligned cells producing a restraining effect on radial shrinkage. However, Panshin and de Zeeuw, (1980), noted that it is related to the rapid reduction of the microfibrilla angle in the cell wall. Result of analysis of variance of radial shrinkage as a result of changes in sampling heights revealed that both radial positions and sampling heights are significantly different at 5% level of probability. Effect of interaction between radial and sampling position was not significantly different at this level as shown in Table 2. The follow up test further revealed that sampling height were different from one another, (Table 1).

Table 1: Mean Value of Radial Shrinkage (%) for the Ecological Zones in Nigeria

		Derived savannah	Sudan savannah	Guinea savannah	Pooled Mean
Sampling height	Radial position				
Base	1	1.35±0.43^{a}	1.29±0.11^{a}	1.33±0.22^{a}	1.32±0.03^{a}
	2	2.91±0.48^{b}	1.99±0.09^{b}	1.89±0.31^{b}	2.26±0.56^{b}
	3	4.38±0.52^{c}	4.21±0.70^{c}	3.96±0.27^{c}	4.18±0.21^{c}
	4	4.10±0.85^{c}	3.99±0.26^{c}	3.77±0.64^{c}	3.95±0.17^{c}
	5	3.02±0.55^{b}	1.95±0.41^{b}	2.11±0.55^{b}	2.36±0.58^{b}
	6	1.43±0.56^{a}	1.28±0.43^{a}	1.34±0.32^{a}	1.35±0.08^{a}
	Mean	**2.87±1.28**	**2.45±1.31**	**2.40±1.18**	**2.57±0.25**
Middle	1	1.68±0.35^{a}	1.36±0.05^{a}	1.41±0.21^{a}	1.48±0.17^{a}
	2	3.32±0.55^{b}	3.25±0.42^{b}	3.33±0.30^{b}	3.30±0.04^{b}
	3	5.00±0.82^{c}	5.20±0.64^{c}	5.10±0.34^{c}	5.10±0.10^{c}
	4	5.13±0.80^{c}	5.21±0.81^{c}	5.00±0.57^{c}	5.11±0.11^{c}
	5	3.49±0.19^{b}	3.44±0.50^{b}	3.31±0.23^{b}	3.41±0.09^{b}
	6	1.87±0.24^{a}	1.35±0.31^{a}	1.43±0.21^{a}	1.55±0.28^{a}
	Mean	**3.42±1.47**	**3.30±1.72**	**3.26±1.62**	**3.33±0.08**

Top	1	3.00±0.24[a]	2.99±0.12[a]	2.81±0.09[a]	2.93±0.11[a]
	2	4.15±0.67[b]	4.00±0.34[b]	3.21±0.21[b]	3.79±0.51[b]
	3	4.99±0.81[c]	4.81±0.56[c]	4.11±0.42[c]	4.64±0.46[c]
	4	5.01±0.92[c]	4.85±0.89[c]	4.23±0.32[c]	4.69±0.41[c]
	5	4.55±0.34$_b$	3.76±0.22[b]	3.42±0.11[b]	3.91±0.58[b]
	6	3.32±0.11[a]	2.68±0.18[a]	2.72±0.21[a]	2.91±0.36[a]
	Mean	**4.17±0.85**	**3.85±0.90**	**3.42±0.63**	**3.81±0.37**
	Pooled mean	**3.49±0.98[a]**	**3.20±0.67[a]**	**3.02±0.55[a]**	**3.24±0.52**

Legend: Mean with the same alphabets in the column are not significantly different from one another for each of the Base, Middle and top at 0.05 level of probability

Mean with the same alphabet in the row are not significantly different form one another for the ecological zones at 0.05 level of probability

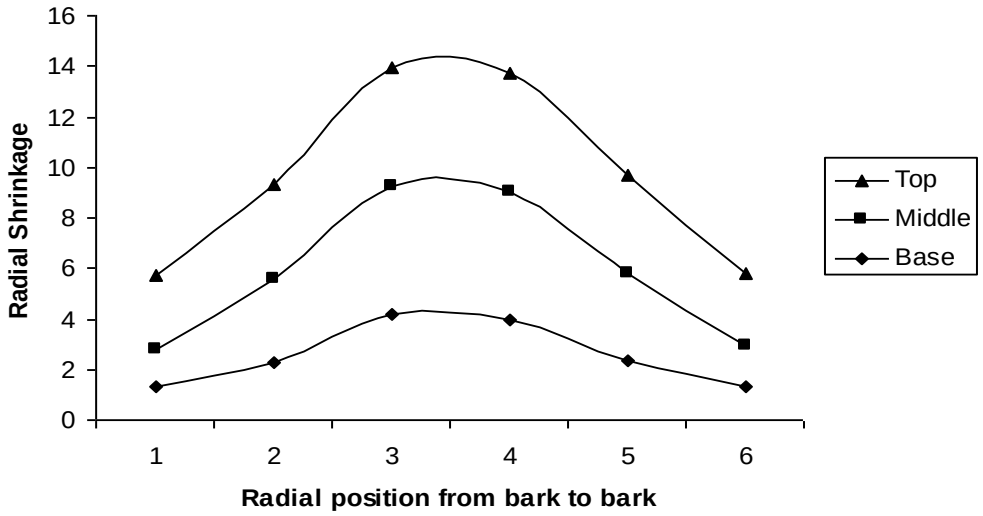


Figure 1: Radial Shrinkage of the wood of *B. aethiopum* with respect to wood samples across the bole

Table 2: Analysis of Variance for Radial Shrinkage

Source of variation	df	Sum of square	Mean of square	F-cal	P-value
Trees (Block)	14	8.24	0.59	0.77	1.000^{ns}
Sampling Height (SH)	2	32.63	16.32	21.47	0.000*
Major plot Error	28	7.37	0.26		
Radial Position (RP)	5	34.93	6.99	9.20	0.000*
Interaction (SH, RP)	10	4.66	0.47	0.62	0.831^{ns}
Sub-Plot Error	210	160.29	0.76		
Total	269	248.12			

Legend:

***=** significant at P<0.05

ns= not significant at P>0.05

Tangential Shrinkage (TS)

The mean tangential shrinkage was 3.71±0.14% with a range value of 2.99±0.37%, 3.67±0.07% and 4.44±0.45% at the base, middle and top respectively (Table 3). Across the bole, it ranges from1.42±0.07% to 4.79±0.89% at the base, 1.98±0.19% to 5.47±0.19% at the middle and 3.18±0.07% to 5.94±1.02% at the top from the back to the centre (Table 3). It was observed that tangential shrinkage increase towards the centre and later decrease towards the bark again as in the case of radial shrinkage (Fig. 2). Ogunsanwo and Ojo, (2011) observed 3.84%. Akira, (1978), obtained 3.6% for the species from Gold Coast (Ghana), Guinea, Sudan and Kenya. Chudnoff, (1976), recorded a mean value of 7.0% for *Aningeria robusta* and Ajala, (2005) recorded 1.35% for the same species while Poku, *et al.*, (2001), recorded a mean value of 4.4%, 6.8% and 4.0% for *Alstonia boonei, Petersianthus macrocarpus* and *Ricinodendrron heudelotti* respectively being lesser-used hardwood species from Ghana. All the species are dicotyledons. However, among the three ecological zones, the highest mean of radial shrinkage was observed in Derived savannah followed by Sudan savannah and Guinea savannah with mean value of 3.96±0.99%, 3.77±0.75% and 3.39±0.86% respectively (Table 3). Generally, a slightly consistent trend was noticed from the base to the top. However, it was at variance with what Poku, *et al*, (2001), observed in *Peterslanthus macrocarpus* and *Ricinodendron heudelotti* from Ghana. They observed that the values increased from the base to the middle and decreased sharply to the top. A sharp decrease was observed from the centre to the bark of the species. The variance of this trend was observed by Ogunsanwo, (2000), on *Triplochiton scleroxylon*. This may be linked with the extent of cell wall development as dictated by the nature of the sampled tree being a monocot. Result of analysis of variance of tangential shrinkage as a result of changes in sampling heights revealed that both radial position and sampling heights are significantly different at 0.05 level of probability. Effect of interaction between radial and sampling position was significant at this level as shown in Table 4. The follow up test further revealed that sampling height were different from one another (Table 3).

Table 3: Mean Value of Tangential Shrinkage (%) for the Ecological Zones in Nigeria

		Derived savannah	Sudan savannah	Guinea savannah	Pooled Mean
Sampling height	Radial position				
Base	1	1.50±0.63[a]	1.39±0.11[a]	1.37±0.51[a]	1.42±0.07[a]
	2	3.18±0.82[b]	2.81±0.11[b]	1.92±0.22[b]	2.64±0.65[b]
	3	4.63±0.92[c]	4.21±0.44[c]	3.99±0.21[c]	4.28±0.33[c]
	4	5.62±1.14[c]	4.91±0.46[c]	3.85±0.07[c]	4.79±0.89[c]
	5	3.44±0.38[b]	2.95±0.81[b]	2.88±0.43[b]	3.09±0.32[b]
	6	1.71±0.77[a]	1.81±0.23[a]	1.57±0.20[a]	1.70±0.12[a]
	Mean	**3.35±0.61**	**3.01±0.35**	**2.60±0.14**	**2.99±0.37**
Middle	1	2.08±0.27[a]	2.11±0.14[a]	1.75±0.40[a]	1.98±0.19[a]
	2	3.44±0.69[b]	3.51±0.32[b]	3.51±0.13[b]	3.48±0.04[b]
	3	5.37±0.71[c]	5.25±0.44[c]	5.41±0.32[c]	5.34±0.08[c]
	4	5.50±1.30[c]	5.27±0.56[c]	5.66±0.44[c]	5.47±0.19[c]
	5	3.69±0.29[b]	3.49±0.41[b]	3.62±0.27[b]	3.60±0.10[b]
	6	2.46±0.42[a]	2.20±0.03[a]	1.89±0.30[a]	2.18±0.29[a]
	Mean	**3.76±0.43**	**3.64±0.39**	**3.64±0.66**	**3.67±0.07**
Top	1	3.24±1.40[a]	3.19±0.31[a]	3.11±0.11[a]	3.18±0.07[a]
	2	4.43±0.47[b]	4.20±0.31[b]	3.99±0.43[b]	4.21±0.22[b]
	3	6.55±0.51[c]	6.11±0.42[c]	4.67±0.61[c]	5.78±0.98[c]
	4	6.78±0.76[c]	6.23±0.41[c]	4.81±0.21[c]	5.94±1.02[c]
	5	3.92±0.41[b]	4.36±0.23[b]	3.87±0.52[b]	4.05±0.27[b]
	6	3.62±0.11[a]	3.81±0.31[a]	3.09±0.05[a]	3.51±0.37[a]
	Mean	**4.76±1.53**	**4.65±1.25**	**3.92±0.73**	**4.44±0.45**
	Pooled mean	**3.96±0.99[a]**	**3.77±0.75[a]**	**3.39a±0.86[a]**	**3.71±0.14**

Legend: Mean with the same alphabets in the column are not significantly different from one another for each of the Base, Middle and top at 0.05 level of probability

Mean with the same alphabet in the row are not significantly different form one another for the ecological zones at 0.05 level of probability

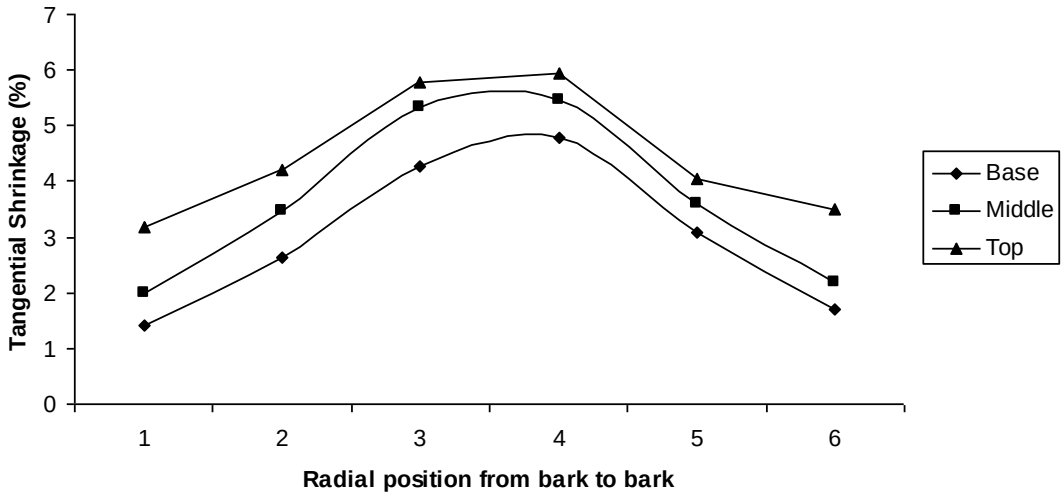


Figure 2: Tangential shrinkage of the wood of *B. aethiopum* with respect to wood samples across the bole

Table 4: Analysis of Variance for Tangential Shrinkage

Source of variation	df	Sum of square	Mean of square	F-cal	P-value
Trees (Block)	14	8.09	0.58	1.57	1.000^{ns}
Sampling Height (SH)	2	48.22	24.11	65.16	0.000*
Major plot Error	28	65.85	2.35		
Radial Position (RP)	5	49.05	9.81	26.51	0.000*
Interaction (SH, RP)	10	32.95	3.30	8.92	0.000*
Sub-Plot Error	210	78.62	0.37		
Total	269	282.78			

Legend:

***=** significant at P<0.05

ns= not significant at P>0.05

Volumetric Shrinkage (VS)

The mean value recorded was 6.94±1.10%, ranging between 5.56±0.58% at the base and 7.01±0.10% at the middle and 8.26±1.90% at the top (table 5), Akira, (1978), recorded a mean value of 3.7% on the same species from Gold Coast (Ghana), Guinea, Sudan and Kenya. The values across the bole range between 2.74±0.09% to 8.75±0.05 % at the base, 3.46±0.30% to 10.44±0.07% at the middle and 6.11±0.17% to 10.64±1.42% at the top. Poku, *et al*, (2001), recorded 7.51%, 11.51% and 6.21% for *A. boonei. P. macrocarpus* and *R. hendelotti*, respectively. The wide disparity could have been attributed to the nature of the wood of trees and probably presence of more biomas in latewood cells as noted by Chudnoff, (1976). A slight increase was also observed from the bark to the centre and later decreases towards the bark again, (Fig 3). Volumetric shrinkage increased from the base to the middle and to the top of the trunk. Radially, it increased to the middle of the wood and then decreased towards the bark again. Panshin and de Zeeuw, (1980), noted that the trend is related to the rapid reduction of the microfibrillar angle in the cell wall and the cellulose content. However, among the three ecological zones, the highest mean of radial shrinkage was observed in Derived savannah followed by Sudan savannah and Guinea savannah with mean value of 7.44±0.76%, 6.98±0.49% and 6.41±0.77% , respectively (Table 5).The result of analysis of variance of volumetric shrinkage as a result of changes in sampling heights revealed that both radial positions and sampling heights are significantly different at 5% level. Effect of interaction between radial and sampling position was not significant at this level as shown in Table 6. The follow up test further revealed that sampling height were different from one another (Table 5).

Table 5: Mean Value of Volumetric Shrinkage (%) for the Ecological Zones in Nigeria

		Derived savannah	Sudan savannah	Guinea savannah	Pooled Mean
Sampling height	Radial position				
Base	1	2.85±0.55^{a}	2.68±0.07^{a}	2.70±0.03^{a}	2.74±0.09^{a}
	2	6.09±0.64^{b}	4.80±0.58^{b}	3.81±0.02^{b}	4.90±1.14^{b}
	3	9.01±0.72^{c}	8.42±0.02^{c}	7.95±0.02^{c}	8.46±0.53^{c}
	4	9.72±0.88^{c}	8.90±0.65^{c}	7.62±0.06^{c}	8.75±0.05^{c}
	5	6.46±0.43^{b}	4.90±0.71^{b}	4.99±0.54^{b}	5.45±0.88^{b}
	6	3.14±0.28^{a}	3.09±0.37^{a}	2.91±0.16^{a}	3.05±0.12^{a}
	Mean	**6.21±0.81**	**5.47±0.63**	**4.99±0.31**	**5.56±0.58**
Middle	1	3.76±0.28^{a}	3.47±0.53^{a}	3.16±0.24^{a}	3.46±0.30^{a}
	2	6.76±0.08^{b}	6.76±0.18^{b}	6.84±0.13^{b}	6.79±0.05^{b}
	3	10.37±0.26^{c}	10.45±0.04^{c}	10.51±0.23^{c}	10.44±0.07^{c}
	4	10.63±0.26^{c}	10.48±0.04^{c}	10.66±0.47^{c}	10.59±0.10^{c}
	5	7.18±0.14^{b}	6.93±0.05^{b}	6.93±0.23^{b}	7.01±0.14^{b}
	6	4.33±0.42^{a}	3.55±0.6^{a}	3.32±0.33^{c}	3.73±0.53^{a}
	Mean	**7.17±0.59**	**6.97±0.11**	**6.90±0.77**	**7.01±0.10**
Top	1	6.24±0.17^{a}	6.18±0.14^{a}	5.92±0.21^{a}	6.11±0.17^{a}
	2	8.58±0.20^{b}	8.20±0.14^{b}	7.20±0.55^{b}	7.99±0.71^{b}
	3	11.54±0.88^{c}	10.92±0.92^{c}	8.78±0.40^{c}	10.41±1.45^{c}
	4	11.79±0.95^{c}	11.08±0.98^{c}	9.04±0.41^{c}	10.64±1.42^{c}
	5	8.47±0.44^{b}	8.12±0.42^{b}	7.29±0.32^{b}	7.96±0.61^{b}
	6	6.94±0.21^{a}	6.49±0.80^{a}	5.81±0.26^{a}	6.41±0.57^{a}
	Mean	**8.93±0.42**	**8.49±0.52**	**7.34±0.41**	**8.26±1.90**
	Pooled mean	**7.44a±0.76**	**6.98a±0.49**	**6.41a±0.77**	**6.94±1.10**

Legend:
Mean with the same alphabets in the column are not significantly different from one another for each of the Base, Middle and top at 0.05 level of probability
Mean with the same alphabet in the row are not significantly different form one another for the ecological zones at 0.05 level of probability

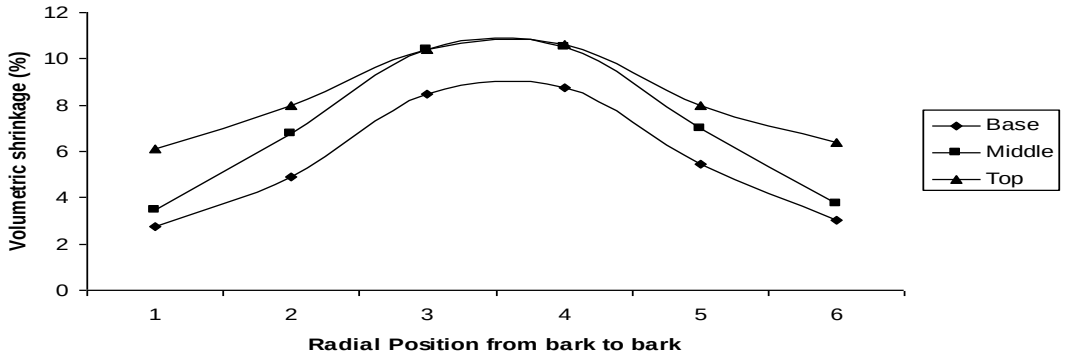


Figure 3: Volumetric Shrinkage of the wood of *B. aethiopum* with respect to wood samples across the bole

Table 6: Analysis of Variance for Volumetric Shrinkage

Source of variation	df	Sum of square	Mean of square	F-cal	P-value
Trees (Block)	14	20.01	1.43	1.43	0.999^{ns}
Sampling Height (SH)	2	171.70	85.85	85.85	0.000*
Major plot Error	28	446.91	15.96		
Radial Position (RP)	5	92.66	8.53	8.53	0.000*
Interaction (SH, RP)	10	13.35	1.34	1.34	1.000^{ns}
Sub-Plot Error	210	210.16	1.00		
Total	269	954.79			

Legend:

***=** significant at P<0.05

ns= not significant at P>0.05

CONCLUSION

The use of lesser-known species for this study has provided useful information as regards the potentials of *Borassus aethiopum* as a good substitute for primary timber species that are going into extinction. Based on the findings of this study, the following conclusions were made. Radial shrinkage decreased significantly across from bark to centre of the bole which also increases from the base to the top. Tangential shrinkage increased consistently from the base to the top. Tangential shrinkage and radial shrinkage are not significantly different from each other unlike in dicot that tangential shrinkage is always twice radial shrinkage. Volumetric shrinkage varied consistently and significantly both along the tree height and from inner wood to peripheral (outer wood). This trend was observed for the three ecological zones

REFERENCES

Ajala, O. O. 2005: Evaluation of the physical and Mechanical properties of the wood of *Annigeria robusta* (A. chev). Unpublished M.phil/Ph.D Thesis submitted to the Department of Forest Resources Management. University of Ibadan. pp 137

Akira Takahashi, 1978: Compilation of Data on the Mechanical Properties of Foreign woods. No 7, Part III (Africa). January, 1978. A monograph published by Matsue: Shimane University.

Arancon Romulo. N. Jr. 1997: Asia-Pacific Forestry Sector Outlook study Working Papers: Focus on Coconut Wood. Working Paper No; APFSOS/WP/23. FAO Paper October 1997. *www.fao.org/forestry/en*. pp 1-36

Chudnoff, M. 1976: Density of tropical timbers as influence by climatic life zones. Commonwealth Forestry Review. 55 (3):203-217.

Desch, H. E. 1988: Timber: Its structure, properties and utilization. 6th Edition. Pub. Macmillian Education. 410pp

Dinwoodie, J. M. 1989: Wood: Nature's cellular, polymeric fibre composite. Pub. *The Institute of Metal London.* pp 138

Evans, P. D. 1991: The strength properties of clear wood materials forum. Vol. 15 pp.231-244)

Lausberg, M. J. F., D. J. Cown., MacConchie and J. H. Skipmith. 1995: Variation in some Wood Properties of *Pseudotsuga menziensii*. Provenancies grown in New Zealand". *New Zealand Journal o*f *Forestry Scienc*e 25 (2): 133- 146

Ogunsanwo, O.Y. 2000: Characterization of Wood Properties of Plantation grown Obeche (*Triplochiton sceleroxylon.* K. Schum) in Omo Forest Reserve. Ogun State, Nigeria, Ph.D Thesis in the department of Forest Resources Management. University of Ibadan. pp 253

Ogunsanwo, O. Y and Ojo, A. R. 2011**:** Density and Dimensional stability of *Borassus aethiopum* (Mart) Wood from A derived savannah zone in Nigeria. *Nigeria Journal of Forestry. Vol. 43.* pp 31-38

Panshin, A. J and de Zeeuw. C. 1980: Textbook of Wood Technology. 4th Edition MacGraw-Hill Book Company. Pp722

Poku, K., Qunglin Wu and Richard Viosky. 2001: Wood Properties and their variations with the tree stem of lesser-used species of Tropical hardwood from Ghana. *Wood and Fibre Science. Journal of the society of wood science and Technology.* Vol.33, No22; 284-291

Sanon, M and Sacande, M. 2007: SEED LEAFLET. *Borassus aethiopum* Mart. No. 120 September 2007. Forestry and Land Scape. Millennium Seed Bank Project. *www.kew.org/msbp*. 2pp

Usta, I. and A. Guray, 2000: Comparison of the shrinkage and swelling of Corcison pine (*Pinus nigra* var. mantima). Turk. Agric. For. J., 24: 461-464.

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Bio Preservative Potential of *Xanthorrhoea preissii* and *Vernonia Amygdalina* Leaf Extracts against Brown Rot Fungi (*Sclerotium rolfsii*) on *Alstonia boonie* (DE. WILD)

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ABSTRACT

The study was conducted to investigate the potential of Xanthorrhoea preissii (Aloe-Vera) and Vernonia amygdalina (bitter leaf) extracts as preservative against brown rot fungi (Sclerotium rolfsii) on Alstonia boonei wood. The wood samples used for this experiment were dimensioned into 20 mm x 20 mm x 60 mm. The plant extracts were obtained by squeezing and soaking was used as method of application on wood sample for 72 h. Data obtained were subjected to analysis of variance at α = 0.05. The result revealed that untreated wood sample has the highest weight loss of 31.60 and 31.60 % for Xanthorrhoea preissii and Vernonia amygdalina leaf extract respectively while the lowest was recorded at 20 % concentration for treated wood samples with 4.63 and 7.76 % respectively. The result of this experiment has demonstrated that the two plant extract could be used as effective bio preservative on wood.

Keywords: Preservative, extract, *Vernonia amygdalina*, Aloe vera.

INTRODUCTION

Wood is sometimes described as the secondary xylem in tree. It can also be define more broadly to include the same types of tissue elsewhere such as in trees, roots or in plants such as shrubs (Hickey et al., 2011). Wood is made up of cellulose (up to 45%), hemi-cellulose (20%-30%), lignin 30%-35% and other substances (Mohebby, 2003). Wood is a hygroscopic material. Some Physical properties of wood are density, swelling, specific gravity and shrinkage. All hygroscopic materials swell and shrink to a lesser or greater extent depending on climate condition (Ola, 2003). It has been revealed that the chemical constituency of wood often dictates wood behaviors (in many respect, and the existence of extractive component in relation to permeability, durability, compressive strength, hardness and specific gravity. It has always been preeminent construction materials for construction purpose worldwide. (Akanbi, 2002).

In Nigeria, wood has always been a preeminent construction material for both domestic and industrial uses. More than 80% of timber product in Nigeria is utilized for construction purpose such as doors, windows, roof tops, propping beam, flooring and panels other important areas of use include; electric and telegraphic transmission poles, furniture and cabinet making tools handle, packaging crate, bridges, carving etc. (Ogbogu, 1996). The increasing importance of wood preservation in Nigeria has been high lightened by Ifebueme and Adedeji (2011), while Ifebueme (1990) stressed on the importance to the wood based industries of the country. Unfortunately, wood preservation in an industries scale has not enjoyed due recognition in Nigeria. There is need therefore to take the benefit of wood preservation to uses for service delivery especially at this stage of this country's development and period of conservation consciousness.

The availability and cost of wood in various forms and sizes together with such properties like mechanical and structural, easy of shaping and fastening including low heat conductivity have made it the outstanding building material from the old age day to the present age. Primarily uses are as fuel or as a construction material for building houses, making tools, weapons, furniture, packaging, art work and paper (Makpa, 2003). Wood can also be used for educational and recreational purposes such as gendering, landscaping, bia-esthetic planning and art. Wood is also used in electricity and telegram transmission, bridge building, carving, furniture making etc. (Elegbede, 2002). The demand for wood and wood products in Nigeria and the world over have continually increase, consumption of sawn wood and wood was placed at 22,668million and 121million respectively in the year 2009 (Hickey *et al*., 2011). Despite the importance and known

advantages of wood, some defects like fungal infection, termites, insect, marine borers, fire attacks and mechanical failure can cause a lot of havoc to the wood (Areo, 2002). Wood preservation is the chemical conditioning of wood in order to increase its resistance to invading destructive organism and deterioration caused by in favourably environmental conditions, to lengthen the life span of the wood in service (Elegbede, 2002). Wood bio deterioration can be defined as the destruction of wood by primarily enzymatic activities of micro-organism, the ability of timber to resist deterioration for a period of time is known as natural durability (Hoardley, 2000).

The term "preservation of timber" refers to any process use to prolong the serviceable life of the timber, while preservatives are toxic chemical substances which are introduced to the wood to make it resistance to bio deterioration and decay (Hiiesaar *et al*., 2001). Wood preservation is the act of introducing toxic substances into wood artificially to make the wood resist the attack and deterioration from biological agents, weather and fire, thus, the service life of such wood can be increased. The level of preservative absorbed and retained in the wood is a function of adequate treatment. A list of recommended practices and specification for wood preservation has been compiled. Practices like steeping or immersion, diffusion process, pressure methods, hot and cold bath, replacement of sap method, and pressure impregnation method. Others include brushing, spraying, dipping etc. (Ifebueme, 1997, Ogbogu 1996, Adeyanju, 2001). These practices are examined and affirmed for the preservation of wood. The importance of wood in the country's economy cannot be over emphasized. Its excellent potential as a structural material can be negated by the attack of deteriorating fungal and insect attack (Hunt and Garath, 2000). Some medicinal plants and other plants products have been reported to possess anti-fungal activities and this is useful in order to substitute for the expensive and sometimes hazardous conventional preservation.

Unfortunately, it is not always possible to attain perfect condition and no timber is entirely immune against bio-deterioration, although some timber are forces, for example, white cypress pine and the river red gum are resistance to termite and some types of borers, tallow wood and cypress pine are highly resistances to weathering and decay (Hickey, and King, 2001). The insecticide and acaricidal properties of a number of plants have been discovered long ago, and some of the plant can compete with synthetic mean of pest and insect control (Sen. Kartal *et al*., 2004). Especially remarkable are tropical plants, from which hundred of product of secondary metabolism with insecticide properties have been extracted (Hiiesaar *et al*., 2001). They are environmental less harmful than synthetic insecticide and acting on many insect indifferent ways. The leave extract of neem is used by farmer to protect cowpea from insect pest on the field. This has prompted the institution for agricultural Research, Zaria to commence research on perfecting of the production and efficiency of the leaf as substitute for imported insecticide that are now very expensive in the country (Tirak, 2006). Termite and fungi is the major wood destroying agent affecting wood in service. They are highly destructive insect. These organism or degradation mainly feed on cellulose materials and attack is a chronic problem in many tropical regions particularly in sub-Sahara Africa, resulting in many tropical monetary and material losses with for reaching impact on the increasing demand of timber (Areo, 2002). Wood can be efficiently protected from termite attack by treating the wood with pesticide effect chemicals. There are many effective preservative chemical used against wood pest in the world, one of the household insecticides used in wood protection against fungal decays, soft rot, insect groups, termites and borers include chemical preservative (Ahmed *et al.,* 2010). Most of these chemicals or synthetics preservative poses were hazard on the health and wellbeing of humans. Some of which, when absorbed through the skin causes chlordane (a severe form of acne) and liver damage e.g. Pentachlorophenol. Chromate copper arsenate is extremely toxic when inhaled or ingested. Skin contact can cause skin irritation and allergies, skin thickenings al loss of pigmentation, ulceration and skin cancer. Creosote is a strong skin and respiratory irritant. Most of these preservatives are human carcinogen and teratogen. The use of bio-preservation substance such as Aloe-Vera gel and *Vernonia amydalina* leaves' extract occurred mostly in the olden day (Akanbi, 2010). One of the major factors contributing to bio-preservative limited selectivity is the question of its long-term natural endurance to the process of natural degradation. The use of bio-preservative poses less hazard to the environment because it is derived from natural plants compared to synthetic preservative which is a combination of different chemicals and this makes up the basis of this research work.

This research investigated the potential of using the leaf extract as preservative. The study therefore, determined the effectiveness of Aloe-Vera gel as preservative against brown rot fungi; and effectiveness of *Vernonia amydalina* extract as preservative against brown rot fungi.

MATERIALS AND METHODS

Materials

Materials use for this project are: Aloe-Vera (*Xanthorrhoea preissii*), Bitter leaf(*Vernonia amydalina*), *Alstonia boonei* wood (Ahun), Kerosene, Distilled water, Brown rot fungi (*Sclerotium rolfsii*), Transparent bowl with cover, Wire mesh, Weighing balance (Sensitive), Measuring cylinder, Circular saw machine, Hand saw, Electric oven, Potato dextrose agar, Ethylated spirit, Cotton wool, Forceps, Sterilize nylon, Disinfectant knife and Writing materials e.g. biro, ruler, pencil and notebook

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Method

Preparation of Wood Block Test

The wood sample (*Alstonia boonei*) was brought from Bodija Plank Market Ibadan, Oyo State. The wood samples was cut into the dimension (20x20x60mm) and labeled. The wood was then dried in an oven at 103 ± 2^0c for 24 hours to determine the moisture content.

Preparation of Extractions

The bitter leave (*Vernonia amydalina*) and Aloe Vera plant were collected at a farmland at new garage area of Ibadan. The bitter leaf was collected fresh and was squeezed for easy extraction. The Aloe Vera plant was also collected fresh; the gel was extract from the plant while the active ingredients present were used. The extract was carried out in the Wood and Paper Laboratory, Federal College of Forestry, Jericho Hill, Ibadan.

Preparation of Test Fungi

The fungus used for this research is the brown rot fungus. The pure culture of brown rot fungi (*Sclerotium rolfsii*) was obtained from Forestry Research Institution of Nigeria (FRIN) Pathology Section, using potato dextrose agar as a culturing medium.

Experimental Design

The wood sample of *Alstonia boonei* is recast 2 x 3 factorial in a Complete Randomized Design (CRD) with three (3) replicates each which gives a total number of 21 wood samples with control.

Method of Analysis

Analysis of Variance (ANOVA) was conducted to examine the level of significant of the treatment applied on the wood sample at different level of treatment based on the weight loss and the absorption rate.

Preparation of Test Fungicide

The volume by volume method was used; this implies that 20ml of the extract (Aloe Vera gel and Bitter leaf) in 80ml of distilled water is equivalent to 20% dilution, the extract was tested using three (3) level of concentration namely: 20%, 40% and 60% respectively in which the control is excluded.

Aloe Vera gel
Treatment 1: 20% of Aloe Vera gel with 80% of distilled water.
Treatment 2: 40% of Aloe Vera gel with 60% of distilled water.
Treatment 3: 60% of Aloe Vera gel with 40% of distilled water.

Biter leaf extract
Treatment1: 20% of bitter leaf extract with 80% of distilled water.
Treatment1: 40% of bitter leaf extract with 60% of distilled water.
Treatment1: 60% of bitter leaf extract with 40% of distilled water.

Application Method

After determine the moisture content, soaking method was adopted for the wood test blocks with the preservatives, and it was allowed to stay in the preservatives for 72 hours, after which the samples were bring out to determine the rate of absorption.

$$\text{Moisture content} = \frac{Initial\ weight - Ovendry\ weight}{Overdry\ weight}\ x\ \frac{100}{1}$$

$$\text{Absorption rate} = \frac{Total\ absortption\ x\ Concentrationx10inkg/m}{Volume\ of\ wood\ x\ Number\ of\ wood\ sample}$$

Percentage weight also was calculated using the formula below:

$$\frac{Weight\ after\ preservative\ application - Weight\ after\ exposure\ of\ fungal\ attack}{Weight\ after\ preservative\ application}\ x\ \frac{100}{1}$$

(Adetogun, 2009).

Test Block Inoculation

Test blocks were treated at each dilution of extract and place in a sterilized plastic containing the test fungi. The control was also place in a sterilized plastic with the test fungi. All test block was labeled properly for easy identification. The block was exposed to the fungi at room temperature of 27^0c for twelve (12) weeks.

RESULTS AND DISCUSION

RESULTS

The moisture content exhibited by wood species was presented in Fig. 1. The result shows that wood samples treated with Aloe-Vera gel had the highest moisture content followed by wood samples treated with bitter leaf had the least moisture content with values of 27±0.40, 25.4±0.38 and 26.2±0.42 respectively. Hence, the grand mean comprised of entire samples were found to be 26.2%. The moisture content obtained could be attributed to the bond water present in the samples. Nurudeen *et al.*, (2011) reported high moisture content (MC) exhibited by wood to be as a result of bond water present in it which aids the microbial activity of the wood, this result is accordance with his finding who reported moisture content of *Ceiba pentandra* and *Triplochiton scleroxylon* to be 34.21 and 12.96 respectively and Dirak, *et al.*, (1999) who reported moisture content of *Pinus caribea* to be range from 24.65 to 35.10.

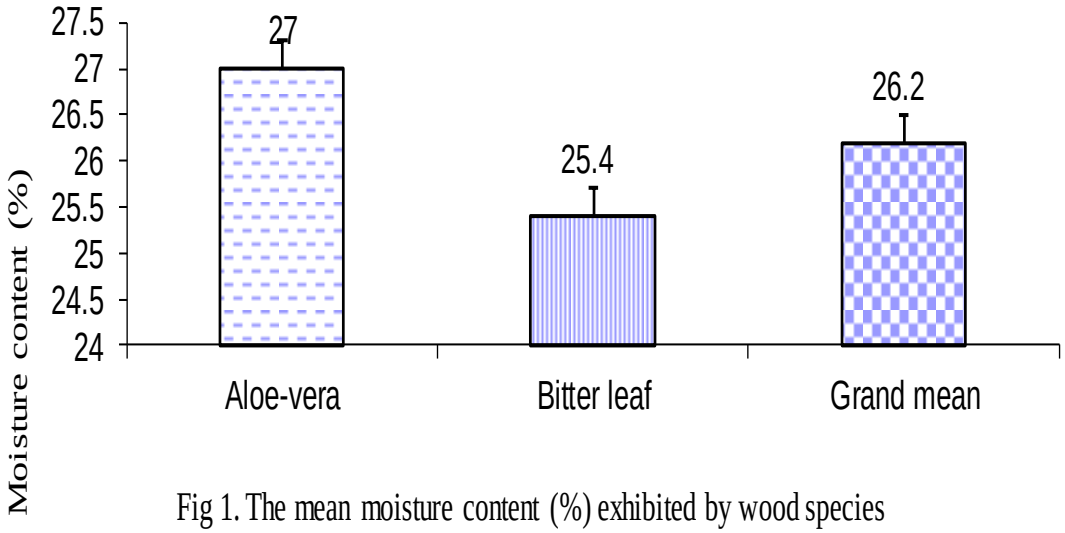


Fig 1. The mean moisture content (%) exhibited by wood species

Adsorption Rate Exhibited by Wood Species in Different Plant Extracts

The absorption rate exhibited by wood species on different extract was presented in Fig. 2. For Aloe-Vera extract, the result showed that the higher the concentration the lower the absorption rate thus implies that the absorption rate is dependent on extract concentration. The higher absorption rate for Aloe-Vera was found in 20% concentration followed by 40% and 60% with value of 22.85, 19.25 and 15.89%, respectively. Bitter leaf on the other hand indicated higher absorption on 40% followed by 20% and 60% with absorption rate of 25.8, 23.6 and 22.75 respectively. The absorption rate obtained could be attributed to the viscosity of the plant extract which is a function of concentration.

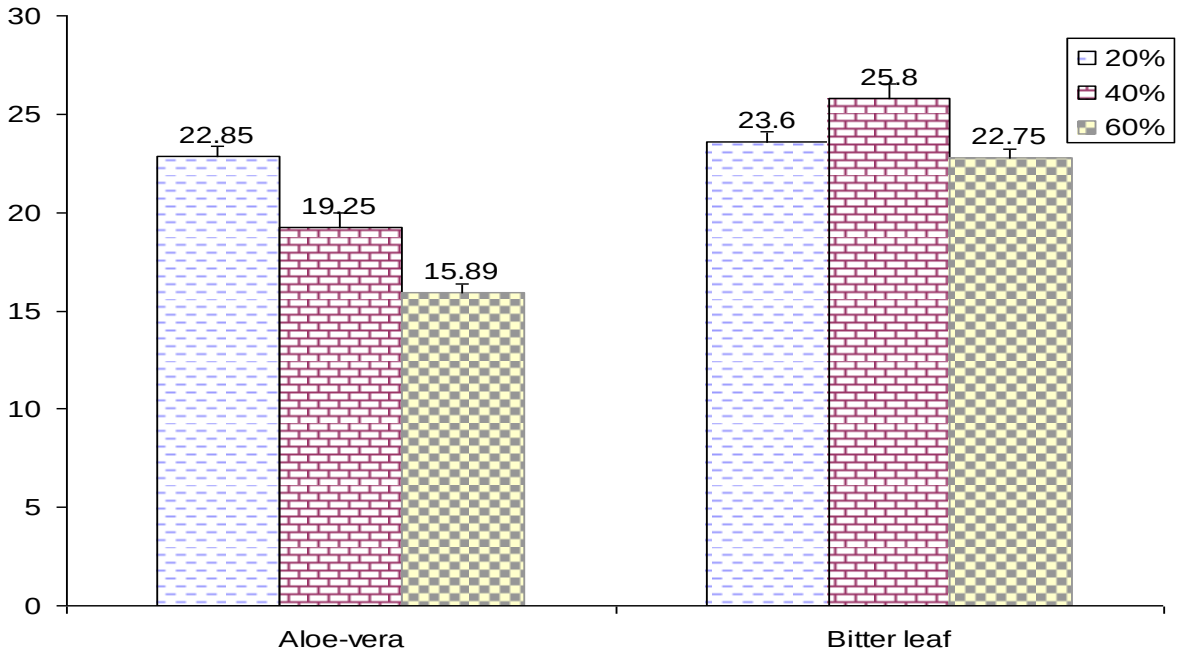


Fig 2. The mean absorption rate (%) exhibited by wood species in different plant extracts

Weight loss due to exposure to fungi attack

Table 1: Show the analysis of variance conducted on wood sample due to exposure of fungi attack was presented in Table 1. The result indicated no significant different occur in extract types ($P \leq 0.05$) but significant different occur in extract concentration ($P \leq 0.05$). This is an indication that the extract used has profound capability in suppressing the fungi attack on wood species. The result is accordance with the founding of Schultz and Nicholas (2002) reported that wood being a natural organic material is degraded by many organism principally fungi and insect. Plant extract could serve as alternative to conventional chemical preservative which pose treat to the environment. The level of fungal attack depends on the durability and density. This plant have been reported to possess anti-fungal activities against some species of fungal (Nurudeen *et al.*, 2011)

Table 1: ANOVA table for weight loss due to exposure to fungi attack

Source of variation	Sum of square	df	Mean square	F	Significant
Extract type	17.30	1	17.30	2.12	0.16
Extract conc.	2564.14	3	854.71	105.06	0.00
Extract *Conc.	8.67	3	2.89	0.35	0.78
Error	1330.162	16	8.135		
Total		23			

Significant at ≤ 0.05

Wood weight loss due to exposure to fungi attack (*Sclerotium rolfsii*)

Tables 2: Show the follow up test conducted on wood species due to exposure to fungal growth. The control sample has the highest weight lost due to fungal attack followed by 20%, 60% and 40% concentration for Aloe-vera gel with their mixed value of 31.60±0.95, followed by 4.63±0.55, followed by 6.10±0.36 followed by 10.89±6.9. Bitter leaf on the other hand, control sample has the highest weight lost followed by 40%, 20% and 60% concentration with their mean weight loss of 31.60±0.95 followed by 13.36±4.44, followed by 7.76±0.29 and 7.29±0.72. This result is an indication that the extract of Aloe-Vera and bitter leaf can serve as a good bio-agent. This resulted to potential eco-friendly. Wood sample treat with this bio-preservative perform more favourable than the control this result show that the selected bio-preservative can serve as alternative to chemical preservation in the wood is a function of adequate treatment so bio-agent such as Aloe-Vera and Bitter leaf protect wood against degrading agent, such as fungal and termite (Aldo and Orlando, 2009).

Table 2: Duncan Multiple Range Test showing the significant in wood weight loss due to exposure to fungi attack (*Sclerotium rolfsii*)

Concentration	Aloe-Vera	Bitter leaf
20%	$4.63+0.55^{b}$	7.76 ± 1.29^{c}
40%	10.89 ± 6.9^{c}	13.36 ± 4.44^{b}
60%	6.10 ± 0.36^{c}	7.29 ± 0.72^{c}
Control	31.60 ± 0.95^{a}	31.60 ± 0.95^{a}

CONCLUSION AND RECOMMENDATION

The efficiency of *Aloe-Vera* gel and *Vernoniaamygdalina* extracts as preservative against brown rot fungi (*Sclerotium rolfsii*) on *Alstonia boonei* is being process in this study. One of the major environmental threat and hazard at alarming rate posed to the global community is pollution and the release of enormous poisonous substances into the environment causing menace to natural balance human health depletion of soil layer, water body, etc.

Since the extracts used in this study is non-toxic, cheap, eco-friendly, biodegradable, and renewable source, it is hereby recommended for the preservatives of wood and also government should endeavor to fund the research like this so as to discover more of valuable wood species that can be suitable for the extract and still compete with the conventional wood preservatives.

REFERENCES

Adedeji A.V (2011): Comparative assessment of the treatment effect of selected bio-preservative on *Alstonia boonie* (De. Wild), *2nd edition, Sun Publisher*, New York, Vol. 2, pg. 69-73

Adeyanju S.K (2001): Wood quality of fourteen savannah timber species in relation to wood preservation, *Obeche Journal* Vol. 13 Pg. 30-49.

Ahmed M.H.M, Ahmed, I.S., Saleh, M.A and I.I Ismail, (2010): The quality of chlopyrifosemilsifiable concrete formulation, *Journa lApplied Sci. Res*, 6:120-127.

Akanbi T.L. (2010): Assessment of preservative effect of *Pakkia biglobosa's* seed extract on *Ceiba pentandra* on exposure to different wood destroying agent, *Journal on agent of wood preservatives* Vol. 13 Pg. 30-49.

Akanbi, M.O, and Ahiru, M.O (2002): A handbook of Forest and Wood insect of Nigeria. *Agbo Areo Publishers*, Ibadan. Pg. 45-75

Areo O.O (2002): Preservative of small round logs of *Tectona grandis* exposed to termite attacks using copper chromium assenate (C.C.A) An HND Project submitted to the Federal College of Forestry, Ibadan.

Dirak M, Alma, M.H, Ilicim, A and Sen. S, (1999): Antibacterial and fungal effects of various commercial plants extracts. *Pharm. Biol*. 37:216-220.

Elegbede M.O (2002): A profile of wood preservation industries in Ibadan and Lagos metropolis. *A project submitted to wood and paper technology in the Federal College of Forestry*, Ibadan Oyo State. Pg. 15-18.

Hickey M, King C (2001): The Cambridge illustrated Glossary of Botanical terms Cambridge University press. Pp. 98-103.

Hiiesaar, K.L, Metspaw, A and Kuusic, S (2001): An estimation of influence evoked. *some natural insecticide on green house insect pest and mite.* Pp. 17-27.

Hoardley R.B (2002): Understanding wood. *A graft man's guide to wood technology.* Tauton press Newton USA. Pg. 1-30.

Hunt G.M and Garath G.A (2000): Wood preservation 3rd edition. *Mc Grew Hill Book Company*. Pp. 433.

Ifebueme S.C (1997): *Natural durability of tropical hard wood species* proceeding of the international workshop on wood preservation held at FRIN Ibadan, Pp. 113-115.

Makpa D.T (2003): The effect of wood moisture content on the *absorption penetration* and *retention of water bornewoodpreservative* of two (2) *Nigeria grown hardwood species* Pg. 118.

Mohebby, B. (2003): Biology attack of acetylated wood. *PhD. thesis submitted to George* – August University Gottingen, Germany Pg. 1-5.

Nurudeen, T.A, Abiola J.K, Ekpo, E.N, Olasupo O.O, Haastrup N.O and Okunrotifa A.O (2011): Effect of plant extracts as preservative against wood decay fungus *Sclerotium rolfsii* (sacc). Pp. 65-67.

Ogbogu G.U (1996): The state of wood treatment technology in *Nigeria Seminar Paper,* presented in FRIN Ibadan Pg. 12.

Ola, M.B (2003): Specific gravity and extractive content in the wood of plantation grown *Sterculia setigera*. *Dec. (Desertification*) University of Ibadan, Nigeria.

Schultz, T.P Nicholas O.D (2002): *Department of environmentally be nigh wood preservations based on the combination of organic biocide with antioxidants andmetalchelators phyto-chemistry* Pp. 555-556.

Sen. Kartal, Amoo-, Onidundu, O.M, Areghan, O.J and Ehijator, S.E (2004): *A journal on ability of natural plant to protect wood against degrading agents*. Vol. 1 Pg 57-60.

.Tirak K., (2006): Increasing fixation properties of plant extraction and tannins, *A Journal on natural wood preservation properties*. *Department of Forestry Industry Engineering* Vol. (3) Pp. 170.

Improving Nigerian Local Honey Trade: A Panacea for Beekeeping Enterprise

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ABSTRACT

Improving the local honey trade is a key to attaining the promises of the beekeeping enterprise in Nigeria. The study was therefore, designed to identify the problems facing the local honey trade and to make recommendations to remedy the situation. Methods used include a review of literature, personal communications, and market survey. Additional data was gathered from NAFDAC and some free advertisement websites. It was found that though interest in beekeeping is on the rise, however, the local honey trade in Nigeria is faced with challenges of poor quality, packaging, and adulteration resulting in consumer loss of confidence and attraction to imported honey. Poor regulation and monitoring were identified as the culprits. Recommendations were therefore, proffered to deal with these problems and put the Nigerian local honey trade on track to achieve the potentials of rural livelihood diversification, income and employment generation.

Key words: local honey, trade, regulation, monitoring.

INTRODUCTION

Honey hunters and traditional beekeepers used to be the only suppliers to the Nigerian local honey market until recently (Oyerinde and Ande, 2006; Babatunde *et al.* 2007). An increasing awareness of the health benefits of honey has led to the proliferation of commercial honey production and an increasing importation of honey in the country (Ezekiel *et al.* 2013). The federal government and some state governments have also promoted beekeeping as a tool of job creation, rural development and livelihood diversification (NAPEP, 2001: Ayansola, 2012: Famuyide *et al*. 2014). Local honey production and trade have therefore grown to some commercial dimensions with about 120 000 beekeepers and a fledging national association of beekeepers (Apiservices, 2010 and Ayansola, 2012). The study is therefore an investigation of the problems facing the local honey trade in Nigeria and a recommendation of ways to overcome them.

RESULTS AND DISCUSSION

Honey production/supply in Nigeria

There is a growing awareness about the potentials of beekeeping and particularly the money making aspect in Nigeria (Ajao and Oladimeji, 2013). An online website by the name *apiservices* reported as at 2010 that there are 120 000 beekeepers, 600 000 beehives in the entire country and each hive produces about 22 kg of honey in a year (Apiservices, 2010). Furthermore, government almost at all levels (local, state and federal) see beekeeping as a tool for rural development and job creation and therefore encourage, promote and support honey production (Ayansola, 2012: Famuyide et al. 2014). For example, the federal government under the national poverty eradication programme (NAPEP) organized a training on honey processing and packaging in 2001 (NAPEP, 2001) and Kaduna state has received support twice from the Australian government to assist in the training of its youths in modern beekeeping through a beekeeping extension society (BES) (Garba, 2015). Hence, honey production is a flourishing enterprise in Nigeria that cuts across almost all the 36 states of the federation (NAPEP, 2001). Moreover, local honey hunters still thrive and supply honey to markets in the rural areas. An example is a village in Abia state where honey hunters display their products by the road side along the express way (Okonkwo, 2016).

However, getting information about these production and supply is a herculean task as it is just not available. The beekeepers' association of Nigeria that should be the repository of information on beekeepers in the country does not have a website. The little that is known of the beekeeping activities in the federating states is gleaned from literature and online articles where authors make some comments about them and not really providing detailed information, such as for example, Charles *et al*. (2010), Oyerinde *et al.* (2012), and Liftedcommodities (2015). The reason for the dearth of information is due to poor documentation of activities, inadequate regulation, and inadequate and poor quality of research. One more reason is that production is usually small scale and scattered (Dia, 2013).

Producer interaction with the honey market

Most beekeepers interact directly with the market. However, there are a growing number of middle men who are either wholesalers or retailers (Dia, 2013, Yohanna and Ja' afar-Furo, 2015, Babalola, 2016 and Mentor health services, 2016) due to increasing demand for honey (Figure I).

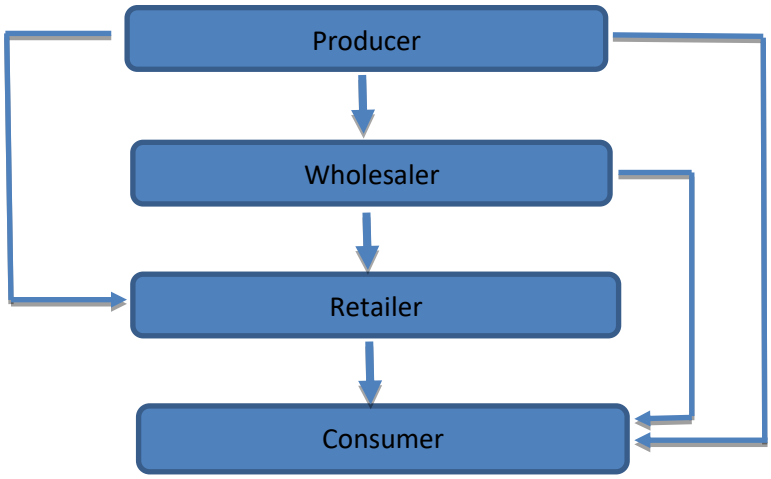


Figure I: Movement of honey from the producer to the consumer in Ganye, Adamawa state.
Source: Yohanna and Ja' afar-Furo, (2015).

More honey traders now use the internet to sell their product, while the default method of selling is to display the products in shops, supermarkets, stores and by the road sides to attract consumers (Okonkwo, 2016). Honey in Nigeria is often sold in 1, 2, 3 litre plastic containers by retailers while wholesalers use lager containers from 5 liters up to 25 liters (Mentor health services, 2016, Babalola, 2016) (Figure II). These containers are usually not labelled and are found in the country in all manner of retail outlets and village markets (Yohanna and Ja' afar-Furo, 2015, Okonkwo, 2016) (Figures II & IV).



Figure II: Honey packaged in containers of varying sizes displayed on the internet.
Source: Advertise.com.ng (2016).

Honey packaging in Nigeria

Many producers, wholesalers, and retailers do not pay close attention to the quality of packaging: used and new containers alike are used to package honey and mostly not labeled (Ja'afar-Furo, *et al*. 2006: Okonkwo, 2016) (Figures II & IV). The phenomenon of poor processing and packaging is responsible for the low pricing of locally produced honey relative to imported honey in Nigeria (Ja'afar-Furo, *et al*. 2006). For example, half a litre of local poorly packaged natural honey goes for less than 4 dollars (Table 1) while the same volume is priced for 10 dollars when it is a well packaged and attractively labelled imported honey (Figure III) (Okonkwo, 2016). Most likely the wrong attitude to packaging evolved due to the fact that friends and relatives, usually, are the first clients of the beekeeper (Lawal and Banjo, 2010) and it is the surplus that is sold to the public. In which case, improvisation is the rule and not the quality of packaging. There is little investigation, by way of research, into the hygiene of the environment of packaging and the container itself. There is really much to be done in the area of ensuring good quality honey and packaging in the local honey trade in Nigeria.



Figure III: Attractively packaged imported honey from the US in Nigeria.
Source: Jiji.ng, (2016).

Table 1: Prices of local honey in Nigeria

S/n	Container size in litres	Price in local currency (=N=)	Dollar equivalence (1 naira = 0.0032 dollar)
1.	½	1 000	3.22
2.	1	2 000	6.45
3.	5	8 000	25.79
4.	10	14 000	45.12
5.	20	24 000	77.36

Sources: Advertise.ng.com (2016) and Google.com (2016).

Nevertheless, there are a small fraction and growing number of honey marketing individuals and small organizations presently who pay attention to quality and are doing proper packaging of honey for the local market in Nigeria. Examples are, Abdulson natural honey, A and shine honey, and R, Q. natural honey (NAFDAC, 2016) (Table 2). Most likely their motivation is to increase the value they get from the honey trade. Furthermore, the food and confectionary companies who use honey as one of their raw materials also package their products in attractive packages (Table 3).



Figure IV: 4 litre honey retail containers displayed on the internet
Source: Jiji.ng, (2016)

Table 2: Some NAFDAC certified local honey companies/products in Nigeria

S/n	Honey company	Product name	NAFDAC no.
1.	Paradise farms Nig. Ltd., Angwar Nasarawa beside rural electrification station, Kaduna town, Kachala lga, Kaduna state.	Abdulson pure natural honey	01-3461
2.	Asunnara enterprises, Aponnite layout, Saki Oyo state.	Multiflora honey	01-3449
3.	Regal quality ltd. 15 Shettu Shagari road Mando, Kaduna.	R.Q natural honey	01-2821L
4.	Baba Oloyin original ventures.100 Osuke road, Iyesi Ota, Ogun state.	Sesan Adewusi honey	A1-4252L
5.	A & shine int'l ltd., technology business incubation centre, fed. mins. of science & tech, off David Mark road, safety, Minna, Niger state	A & shine honey 1200g & 500g	01-0626

Source: NAFDAC, (2016).

Table 3: Some food products with honey in Nigeria

S/n	Product name	Ingredients	NAFDAC no.
1.	Ginger tonic	Ginger oleoresin extract and pure honey extract	01-3450
2.	Chifine orange flavoured drink	Water, orange flavour, sugar, honey syrup, acidulant (citric acid), sodium benzoate, glucose, orange base & vitamin c	01-6985
3.	J.T honey with garlic tonic	Honey and garlic juice	01-3807L
4.	J.T honey with ginger tonic	Honey and ginger juice	01-3991L
5.	Ok foods all butter shortbread	Honey, sugar, whole milk powder, veg. fat, wheat flour, salt	01-3694

Source: NAFDAC, (2016).

Honey regulation in Nigeria

The local honey trade in Nigeria is poorly regulated. For example, according to the statistics of Apiservices (2010) there are 120 000 beekeepers in Nigeria, however, records from the National Agency for Food and Drug Administration and Control, NAFDAC (2016) website show that there are only 75 (0.063%) of these that are registered with the regulatory body. For this reason, poor quality, adulterated and fake honey and honey products are today serious problems affecting honey trade within Nigeria (Adeola et al. 2011). This is the underlying basis of the proliferation and popularization of imported honey in the country (Table 4). Because consumers (especially the elites and higher income earners) have more confidence in the quality of imported honey than local honey and honey products due to proper labelling and attractive packaging (Ibegbulam, 2007: Adeola et al. 2011) (Figure III). This is accentuated by the fact that imported honey comes with an approval of quality code (commonly known as NAFDAC number) on the label (Table 4).

Table 4: Some certified imported honey in Nigeria and their country of origin

S/n	Product name	Country and company of origin	NAFDAC no
1	Forever bee honey	Aloe Vera of America Inc. 9660 Dilworth road, Dallas Texas, 75243, USA	01-3412
2	GNLD honey	GNLD Int'l (pty) ltd. 54 steel road, Spartan 1619, Gauteng, South Africa	01-4070
3	Goya pure honey	P. T. Tanjung Mahligai Abadi Sidorjo, Indonesia	01-3754
4	Laser pure blossom honey	Sun-oil ltd. unit c, St. Leonard road, London n10110657	01-4284
5	Gold honey	Gold Kili trading enterprises (Singapore) pte, limited, 48, Senoko drive, Singapore, 758231.	01-6365

Source: NAFDAC (2016)

NAFDAC monitors the quality of food and drug in the country and has a strong reputation for doing a good job. Unfortunately, NAFDAC has been unable to keep track with locally produced honey. Hence, only a small number of local honey producers/marketers are captured by NAFDAC (Table 2 & 3). The cost of getting NAFDAC certification is also a likely obstacle to local honey certification since most marketers and producers are small scale it means that they cannot afford it. Therefore, with poor enforcement of regulatory policies and laws, traders can continue to bring poor quality product to the market with almost no sanctions or repercussions and inadvertently honey trade in Nigeria is largely informal, unmonitored and unrecorded.

CONCLUSION

There is a rising interest in the beekeeping enterprise in Nigeria. The Nigerian local honey trade is however hampered by poor product quality, packaging, and adulteration. Factors underpinning these ugly trends are poor regulation and monitoring. Despite the fact that consumers have lesser confidence and trust in the quality of local honey, imported honey, though almost three times more expensive, is more attractive to consumers, especially to the higher income earners and the elites. There is therefore, the need to address these issues in order to improve the local honey trade and achieve its potential of rural livelihood diversification, income and employment generation.

RECOMMENDATIONS

Beekeeping is a non-timber forest product (NTFP) based enterprise, the Forestry Research Institute of Nigeria (FRIN), and other forestry based organizations and associations in the country have a great role to play in the development of the sector. Therefore, they are to find ways to:

- synergize with the beekeepers' association of Nigeria (BAN) to assist in the improvement of beekeeping methods, data collection and record keeping.

- Monitor the honey market from time to time for quality.
- assist the beekeepers to form unions to process, package and certify honey with NAFDAC.
- involve FRIN for instance to develop laboratory for honey testing that can be used for monitoring.
- disseminate of information on the standard honey quality and packaging.

REFERENCES

Adeola, A. O., Bifarin, J. and Folayan, J. A. (2011) Honey marketing in Ibadan metropolis of Oyo state, Nigeria: an economic analysis. *Journal of Agricultural Science*, 2 (2): 113-119.

Advertise.com.ng (2016) For sale: Drums, Litres of undiluted natural honey. http://lagos-lagos.advertise.com.ng/for-sale%3A-drums%2C-litres-of-undiluted-natural-honey-18460.html, (Accessed 26 June 2016).

Ajao, A. M. and Oladimeji, Y. U. (2013) Assessment of contribution of apicultural practices to household income and poverty alleviation in Kwara state, Nigeria. *International Journal of Science and Nature,* 4 (4), 687-698.

Apiservices, (2010) Beekeeping-Apiculture-Nigeria. http://www.beekeeping.com/countries/nigeria.htm. (accessed 19 July 2016).

Ayansola, A. A. (2012) An appraisal of apicultural practices in southwestern Nigeria. *Journal of Agricultural science, **3** (2): 79-84.*

Babalola, (2016) *Personal communication.* 3 February, 2016

Babatunde, R.O., Olorunsanya, E.O., Omotesho, O.A. and Alao, B.I. (2007) Economics of honey production in Nigeria: Implications for poverty reduction and rural development. *Global approaches to extension practice (GAEP),* **3** (2): 23-29.

Dia, Y.Z., Mshelia, S.I., Zalkuwi, J. and Gwandi, O. (2013) A structural analysis of honey trade flow into Ganye and Toungo local government areas of Adamawa state, Nigeria. *Greener Journal of Business and Management Studies*, 3 (4): 174-179.

Ezekiel, A. A., Olagunju, F.I. and Olapade-Ogunwole, F. (2013) Economics of honey production in Oyo State, Nigeria. *Global advanced research journal of arts and humanities (GARJAH),* **2** (2) 43-47. Available at: http://garj.org/garjah/index.htm. (Accessed 5 July 2016)

Famuyide, O.O., Adebayo, O., Owese, T., Azeez, F.A., Arabomen, O., Olugbire, O.O and Ojo, D. (2014) Economic contributions of honey production as a means of livelihood strategy in Oyo State. *International Journal of Science and Technology* **3** (1): 7-11.

Garba, J. (2015) Australia approves N6m for bee-keeping in Kaduna. www.authorityngr.com. (Accessed, 8 August 2016) Google.com (2016) Naira dollar exchange rate. https://www.google.com/?gws_rd=ssl#q=Naira+dollar+exchange+rate. (Accessed 26 July 2016).

Ibegbulem, J. A. (2007) Evaluation of honey from some states in Nigeria by the determination of pollen spectra, physico-chemical parameters, anti-bacterial activity and consumers' acceptance. Ph.D. dissertation in the department of biological sciences, Ahmadu Bello University, Zaria, Nigeria.

Ja'afar-Furo, M. R., Sani, R. M., Kushwaha, S. and Hamidu, B. (2006) Economic analysis of smallholder beekeeping industry in Adamawa state, Nigeria. *Global Journal of Pure and Applied Sciences*, 13: 23-26.

Jiji.ng, (2016) Natural dietary supplements in Nigeria. http://jiji.ng/supplements/natural.

Lawal, O. A. and Banjo, A. D. (2010) Appraising the beekeepers' knowledge and perception of pest problems in beekeeping business at different ecological zones in southwestern Nigeria. *World Journal of Zoology*, 5 (2): 137-142.

Liftedcommodities, (2015) Nigeria agricultural products for export. http://www.liftedcommodities.com/?linkProvidedBy=WANDInc, (Accessed 26 June 2016).

Mentor health services, (2016) *Personal communication.* 20 June, 2016.

NAFDAC, (2016) Product registration and registered products. http://www.nafdac.gov.ng/index.php/product-registration/registered-food-products. Accessed 21 July 2016.

National poverty Eradication Programme (NAPEP), (2001) Training module for honey processing and packaging. The presidency: Federal Republic of Nigeria.

Okonkwo H. O. (2016) Honey marketing in Nigeria field survey data. *Unpublished.*

Oyerinde, A. A., and Ande, A. T. (2006) A preliminary assessment of modern apicultural practice in Kwara state Nigeria. *Journal of agricultural research and development,* 5 (2): 203-214.

Oyerinde, A. A., Dike, M. C., Bamaiyi, L. J., and Adamu, R. S. (2012) Comparative studies of behaviourial variations of *Apis mellifera* L. species in Nigeria. *Global Journal of Science Frontier Research Agriculture and Veterinary Sciences*, 12 (7), version 1.0: 42-46.

Yohanna, K. and Ja'afar-Furo, M. R. (2015) Evaluation of Honeybee Products Marketing in Nigeria: An Experience from Ganye Region, Adamawa state. *International Journal of Sustainable Development*, 8 (10): 29-36.

Awareness on Phytosanitary Measures for Pest Control in Timber Processing and Handling

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ABSTRACT

Phytosanitary measures are management techniques used to prevent unintentional movement of insect pests during timber processing and handling. In this study, the level of awareness on phytosanitary measures used for insect pest control during timber harvesting and post harvesting operations were assessed in Osun, Oyo and Lagos State, Nigeria. Questionnaires (331) were administered to plank marketers, saw mill workers, plant quarantine service workers, forestry officials and tree loggers in the three states. Information on knowledge about phytosanitary measures, pest control and perceptions towards pest infestation were elicited. Data were analysed using descriptive statistics, chi square and logit regression analysis at $\alpha_{0.05}$. The respondents (80.0%) noticed pest infestation in their timber/planks before selling and 93.3% claimed that there were no regulatory bodies in charge of pest management in the forestry sector. The plank marketers used chemical (34.2%) and biological treatments (0.8%) for pest control while saw mill workers used chemical method (42.3%) and painting (4.9%). Logit regression analysis showed that awareness on phytosanitary measures had a positive impact on the willingness of the respondents to adopt the use of phytosanitary measures with an odd ratio of 13.50. Pest infestation resulted in reduced income and poor quality of wood products. There is therefore, a need for concerted efforts to generate interest in pest control using phytosanitary measures.

Keywords: Integrated pest management, timber processor, phytosanitary measures, wood preservation

INTRODUCTION

Healthy forests are vital to the healthy state of ecosystems, because they are capable of self-renewal; resilient in their response to natural and artificial disturbances (pests, fire, and human-caused disturbances). Thus, forests are able to sustain the integrity of the natural and cultural benefits (ISPM, 2010; Rosenberger and Smith, 1997). Insect pests live in and on trees, consuming their leaves, bark, wood and roots for food, protection and shelter. Forest products thus contain insects which can serve as pests when their populations exceed economic injury levels. These small invertebrate herbivores are capable of damaging forest trees while constituting a major source of loss of wood products (Beal, 1981; FAO, 2011). Insect pests cause damages to trees in all stages of their development and affect the ability of both natural forests and plantations to meet the forest management objectives (FAO, 2001). There is a large variety of insects that attack timber during various stages of its utilization, starting from trees felled in the forest, down to stage of processing and utilization (Nair, 2007).

Forest managers need to be aware of the potential impacts that these pests may have on the quantity and quality of benefits derived from forests (Averill *et al.*, 1995). Phytosanitary measures are legislative and official actions pertaining to plant quarantine, which are used during timber harvesting and post harvesting operations in order to prevent the movement of pest or invasive species from one place to another. These measures and regulations serve as preventative management to avoid unintentional movement of any form of pests (GISD, 2008). Low level of awareness of phytosanitary measures among plank marketers, tree loggers and saw millers can lead to the spread of pests on timber species of economic importance. The appropriate handling of timber and timber products by these stakeholders, therefore, has its importance in pest control. This is because the necessary phytosanitary measures which are supposed to be in place during timber harvesting and post harvesting operations may not be undertaken. These may result into pest infestation and inoculation, loss of aesthetics value and subsequent loss of income. It also limits the expansion of the forestry industry to international markets (FAO, 2011).

Pests can have detrimental effect on the durability and appearance of timber; causing aesthetic and structural damages as well as economic loss. Pest and insect that attack trees and fresh logs frequently bore and live in the inner bark of the tree for a variable period of time, before they penetrate the wood (Haack *et al*., 2010). The level of awareness on the need for phytosanitary efforts in timber harvesting and processing will improve the handling processes and the management of the renewable resource. Consequently, when phytosanitary

measures are carried out during forest operations and particularly during harvesting operations, they help to reduce the incidence of disease outbreak within the forest (FAO, 2011). This study determined the level of awareness on of the use of phytosanitary measures during timber harvesting and post harvesting operations among the tree loggers, saw millers and forestry officials.

MATERIALS AND METHODS

Study Area

This study was carried out in Osun, Oyo, and Lagos states. Six saw mills containing timber markets were purposively selected: Orisunbare and Isokan saw mills (in Ikoyi and Ikire, Osun State); Alomaja and Temidire saw mills (in Ibadan, Oyo state) and Oko Oba saw mill (in Ebute-Meta, Lagos State) (Figure 1). Three hundred and thirty one structured questionnaires (Table 1) were administered to: forestry officials (43), plant quarantine officers (10), tree fellers (35), saw mill workers (123) and plank marketers (120). The plant quarantine officers were interviewed in the National Agricultural Quarantine Centre, Ibadan while forestry officials were sourced from the Department of Forestry in each state. The questionnaires were used to elicit information on the level of awareness on phytosanitary measures in timber processing, the effect of pest infestation on value of forest products and the methods used for controlling insect pests. The qualitative data were analysed using descriptive statistics, chi-square and logit regression analysis.

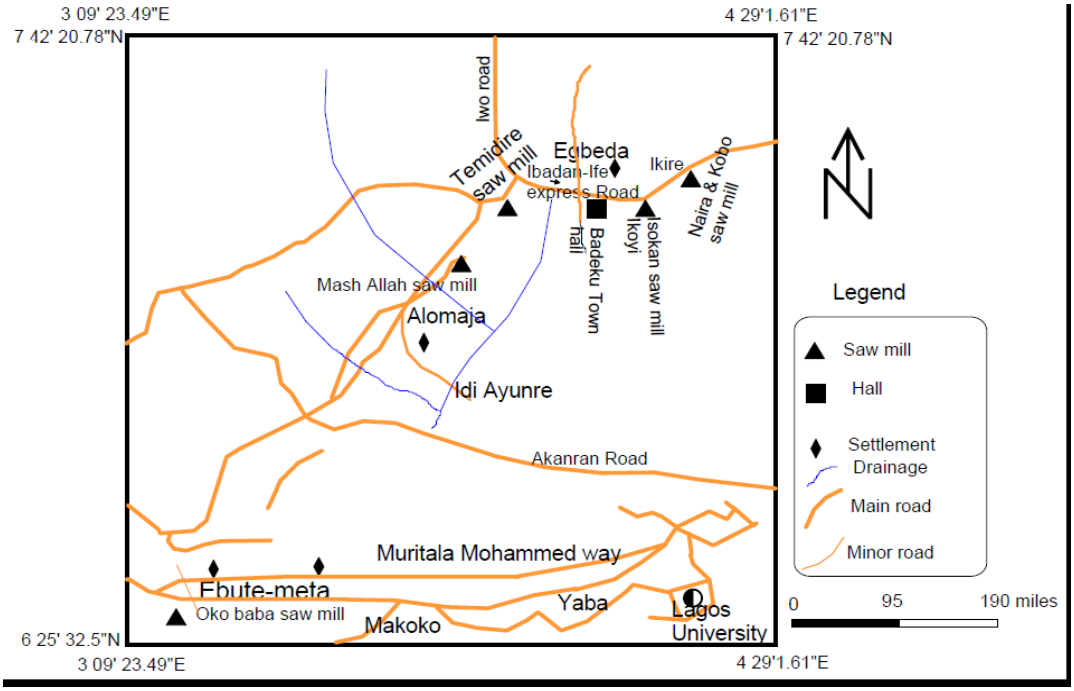


Figure 1: Map showing the location of selected saw mills in Osun, Oyo and Lagos states

Table 1: Number of respondents interviewed in the selected locations in Osun, Oyo and Lagos states

State	Description	Plant quarantine officers	Forestry officials	Tree loggers	Saw mill workers	Plank marketers	Total
Osun	Ikoyi and Ikire	-	17	5	50	20	92
Oyo	Ibadan	10	19	30	23	50	132
Lagos	Ebute-metta	-	07	-	50	50	107
Total	4	10	43	35	123	120	331

RESULTS

Knowledge of Phytosanitary Measures

The forest managers and plant quarantine officers had little training in pest identification with 83% of the respondents lacking basic knowledge on insect ecology. In the plank markets, 21.7% of the respondents admitted that the pests had a negative effect on the sale of wood products while an alarming 77.5% sold infested planks without any form of treatment. In saw mills, 74.8% had insect pest occurrences, while 79.7% of saw mill workers checked the health of their logs before sawing. Plank marketers (30%) had heard about phytosanitary measures. Among the 30% of plank marketers, 4.2% got information about phytosanitary measures from forestry officials, 0.8% through Integrated Pest Management, 3.3% from Agricultural Extension Agents and 26.3% through other means. A large number of saw mill workers (81.3%) had no knowledge of phytosanitary measures with 12.2% of them obtaining information from forestry officials, while 0.8% claimed to get information about pest management from their colleagues. It was discovered that the overall number of the respondents that had not heard about the phytosanitary measures were 84.6%.

Sources of Information on Phyto-Sanitation

Forestry officials and plant quarantine officers (41.5%) had adequate knowledge of phytosanitary measures in timber production. The sources of information were National Plant Protection Organization (24.5%), International Plant Protection Convention (5.7%), Integrated Pest Management protocols (5.7%), while 5.7% got the information from their colleagues (Fig. 2). Nonetheless, a large percentage of them confirmed that it was not in use (Fig. 3). For plank marketers, the location, gender and educational background had significant effects on the level of awareness about phytosanitary measures (Table 2). The logit regression revealed that only the phytosanitary awareness and pest information records influenced the willingness to use such methods for insect pest management and control (Table 3).

Table 2: Influence of selected variables on the level of awareness about phytosanitary measures in plank markets, saw mills and among tree loggers

	Plank markets		Saw mill		Tree loggers	
Variable	Chi square value	P value	Chi square value	P value	Chi square value	P value
Location	25.48	0.000*	0. 303	0.859ns	0. 303	0.859ns
Gender	10.57	0.001*	0. 368	0.544ns	0. 368	0.544ns
Marital Status	0.005	0.945ns	2. 149	0.143ns	2. 149	0.143ns
Education	30.68	0.000*	8.997	0.061ns	8.997	0.061ns
Experience	5.18	0.159ns	2.278	0.685ns	2.278	0.685ns

ns = not significant, * = significant at $p < 0.05$

Table 3. Logit regression on willingness of the respondents to use phytosanitary measures

Independent Variable	Coefficient model	Odds-ratio	p-value
Gender	0.365	1.44	0.511ns
Marital status	0.406	1.5	0.596ns
Pest Infestation Record	-1.294	0.273	0.024*
Phytosanitary Measures Awareness	2.603	13.50	0.000*
Age	-0.018	0.981	0.450ns

Final Loss = 55.281; Chi Square value = 26.918; df = 5; p = 0.00006

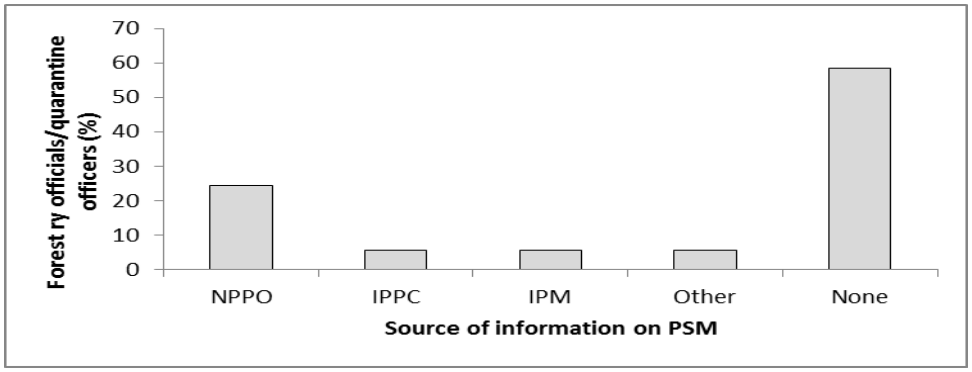


Figure 2: Sources of information about international phytosanitary measures recommended for timber harvesting, processing and handling (NPPO: National Plant Protection Organization, International Plant Protection Convention, Integrated Pest Management)

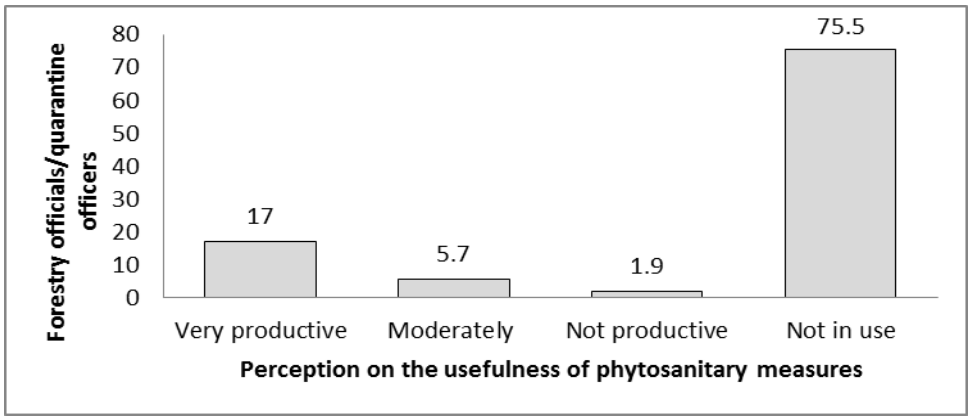


Figure 3: Perception of forestry officials and plant quarantine officers on the usefulness of phytosanitary measures

INSECT PEST INFESTATIONS

Although, 80.8% of the timber processors and handlers had noticed pest infestation in their timber/planks before selling, 93.3% claimed that there was no regulatory body in charge of pest management in the forestry industry. However, 4.2% had reported previous pest infestations to government agencies and requested for assistance. Nonetheless, most of the timber processors perceived that insect pest infestations had little negative impact on the value of their products, with all tree loggers opining that there was no negative effect (Fig. 4). Consequently, a larger proportion of the respondents continued the sale of infested products (Fig. 5). Ironically, majority of the respondents agreed that the pest reduced their accruable income (Fig. 6). Two coleopteran insect pests were commonly observed in the surveyed saw mills (*Bostrychoplites cornutus* and *Alaus excavates*).

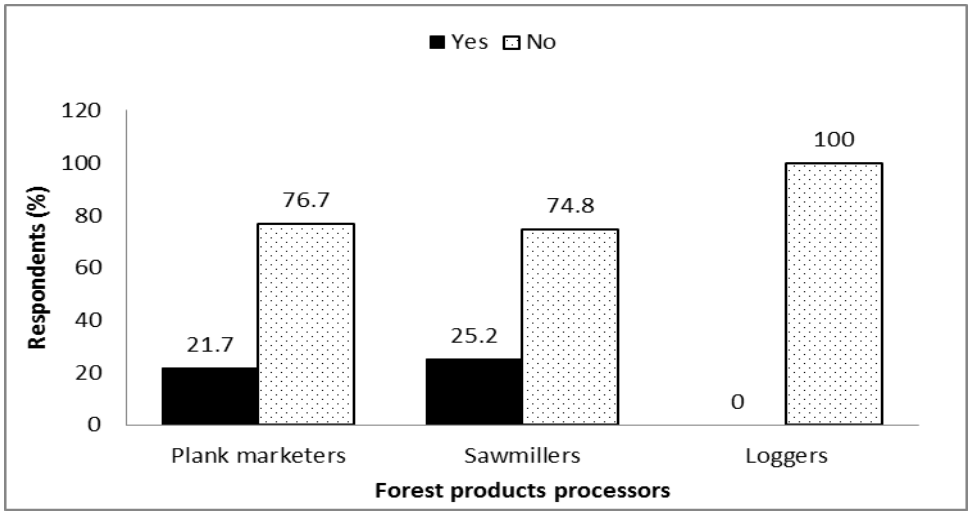


Figure 4: Perception of forest product processors on the effect of insect pests on the value of their products

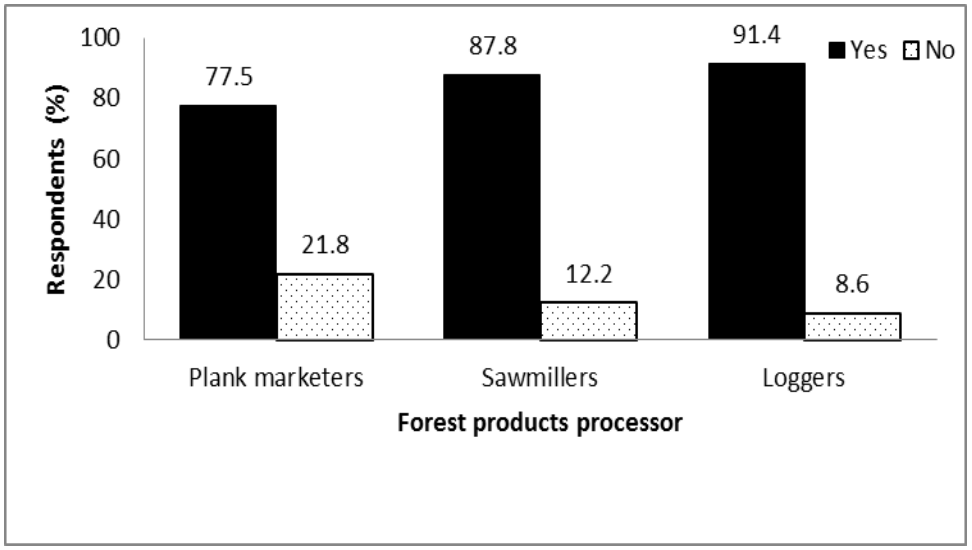


Figure 5: Number of timber processors and plank marketers who sold infected products to their customers

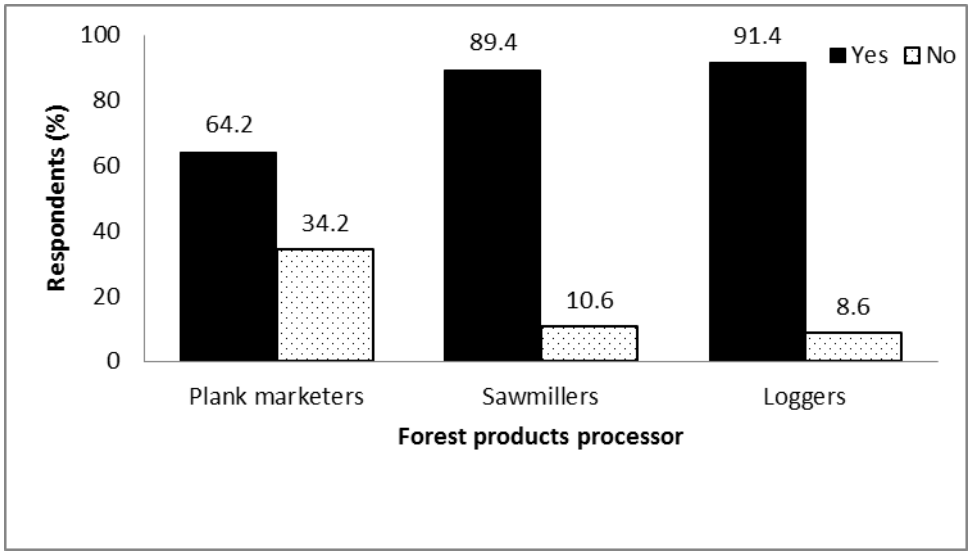


Figure 6: Perception of respondents on the negative effect of infested products on accruable income

Local Pest Control Measures

Some methods used for pest control included: chemical and biological treatment, with most respondents not using any treatment (Fig. 7). A common technique was the sorting of infected planks from uninfected ones in plank marketers. In the saw mills, some of the methods used included heat treatment (2.4%), irradiation (0.8%), fumigation (25.2%), debarking (34.1%) and others (4.1%).

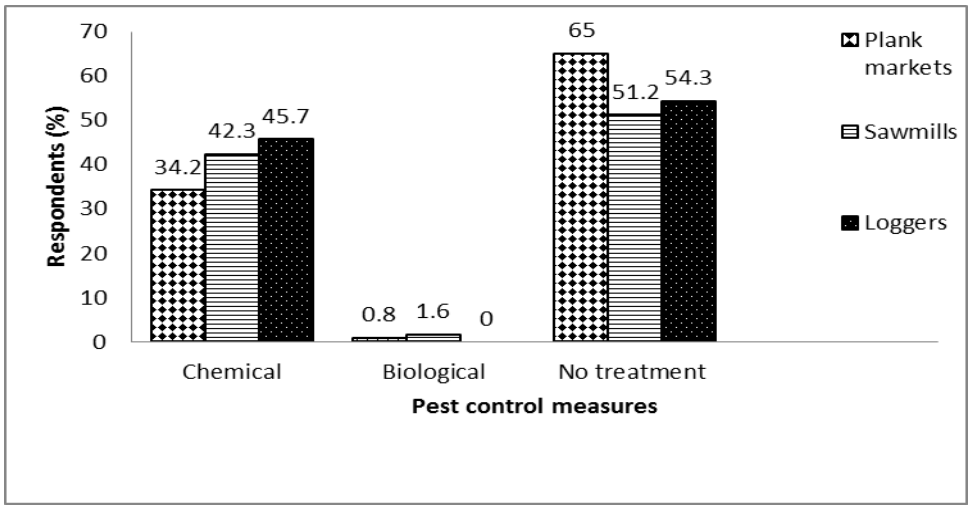


Figure 7: Insect pest control measures used by forest product processors

DISCUSSION

Awareness on Phytosanitary Measures

The level of awareness on phytosanitary measures in timber harvesting and post harvesting is very low. The study revealed that 81.3% of the saw mill workers had not heard about phytosanitary measures, irrespective of location, gender, educational background, marital status, and year of experience. This was despite the high rate of pest infestation and damages observed in the saw mills. This low-level of awareness could be partly attributed to poor dissemination of information from appropriate authorities (FAO, 2011). A large number of respondents however believed that phytosanitary measures were preventive measures that could limit pest infestation in wood.

Institutional Support for Timber Handlers

The direct movement of pests from the forest into saw mills has been attributed to be the main source of infestation of wood products (FAO 2011; Ren *et al.,* 1997). Many of the saw mill workers complained about the lack of information from forestry officials, who collect revenue from them and approved the renewal of their saw mill licenses. However the presence of pests in the harvested logs did not prevent their conversion to planks as it was believed that the processing could help reduce or eliminate some of the pests (Ren *et al.,* 1997). Although, sawing exposed the pests to the vagaries of the environment, thus resulting in a temporary initial reduction in their population, eventually, their larvae could cause further infestation on the site resulting in secondary damage at various stages of utilization (FAO, 2001, Nair 2007). The tree loggers opined that pests were part of the habitats and could not limit their income from the forest. It was also discovered that there was no mechanism in place for transfer of information from the government agencies to tree loggers. Forestry officials are supposed to be the custodians of information that could help in preventing the movement of pest from one place to another, but most were not aware of phytosanitary measures (Fig. 2 and 3) with the exception of quarantine officers, who were experts in the procedures for exportation of forest products from Nigeria, in accordance with International Standards for Phytosanitary Measures (GISD, 2008). Thus, forestry officials require capacity building to be able to pass this knowledge to stakeholders handling forest products. The logit model revealed that pest infestation records and phytosanitary measures awareness with odd ratios of 0.273 and 13.50 respectively, were the major independent variables that influenced willingness to use phytosanitary measures (Table 3). This implies that stakeholders with pest infestation records and knowledge on phytosanitary measures were most likely going to adopt the measures.

Pest Attack on Wood Products

Pest degradation reduced the quality of the wood products and resulted in high losses of stored planks. The plank marketers sold infested planks at lower prices and some planks were sold as firewood. Plank marketers also complained about the negative effect of these pests on their health which included insect bites, skin infections and wounds. However, tree loggers did not see pest infestation as a major problem probably due to the healthy and diverse nature of the tropical forest (Rosenberger and Smith, 1997; ISPM, 2010). Pest infestation was prevalent in plank markets, although they could not specifically identify any of the insects. Many of them discovered the infestation without knowing how the insect got into their store, suggesting that the infestation may be traced to larvae inoculation from the forests (Beal, 1981; Douce *et al.,* 2002). These infested planks are sold to buyers without any form of treatment. This increases the likelihood of wood failing in service and the insect population being spread to other areas (FAO, 2011). Knowledge of pest identification and biology with forestry management practices may help to prevent losses to these pests (Douce *et al.,* 2002).

Treatment and Marketing of Infected Wood Products

There was no regulatory agency to control chemical use with chemicals such as D-D force, timber guard, solignum and Gamalin 20 being sold in the open market without control. After sorting, the infested planks are separated from uninfected ones and then chemical treatments are used to prevent further infestation. The infested planks are categorized into different levels such as neat, rough and jacket, depending on the level of damage. The rough ones are sold as fire wood, resulting in losses to the marketers and the movement of particular pest into new environments. The method used by the tree loggers in the forest site included fumigation, while 40.0% did not embark on any form of treatment. In addition, there were no precautionary methods to reduce further spread as logs with or without pests are loaded together in trucks and transported from the forest site into the saw mills. There is therefore need for monitoring and surveillance programs in order to curb the spread of forest pests (Basavaraju *et al.,* 2010). Many trees from the forest that could have been used for furniture and construction work have been destroyed by pests and insects; however with proper management losses could be drastically reduced (Robert, 2012; Rosenberger and Smith, 1997).

CONCLUSION AND RECOMMENDATION

hytosanitary measures enhance wood processing and utilization, while controlling pest movement and infestation. Pest damage to forest product cause a loss of income to plank marketers, saw mill workers and tree loggers. The creation of awareness on the benefits of phytosanitary measures need to be intensified in order to reduce damage of wood products during processing and utilization.

REFERENCES

Averill, R.D. Larson, L., Saveland, J. Wargo, P. Williams, J. and Bellinger, M. (1995). Disturbance processes and ecosystem management. Washington, DC : U.S. Department of Agriculture, Forest Service. Pp13.

Basavaraju B.S, Chakravarthy, A.K, Doddabasappa, B., Nagachaitanya. B., and Yathish K.R. (2010). Threats to natural resources by insect invasives. *Karnataka Journal of Agricultural Science* 23: 1-5.

Beal, R.H. (1981).Termite control studies in Panama.US Department of Agriculture, Forestry Service and Resources 50-56.

Douce, G.K., Moorhead, D.J., and Bargeron, C.T. (2002). Forest pest control. *The University of Georgia, College of Agricultural and Environmental Sciences*, Special Bulletin 16, Revised January 2002.

Food and Agricultural Organization (2011).Guide to implementation of phytosanitary standards in forestry. FAO Forestry Paper No. 164

Food and Agriculture Organization (2001). Protecting plantations from pests and diseases. Report based on the work of W.M. Ciesla. Forest Plantation Thematic Papers, Working Paper 10. Forest Resources Development Service, Forest Resources Division. FAO, Rome.

GISD, (2008). Global Invasive Species Database: *Adelgespiceae*. Available from: http://www.issg.org/database/species/ecology.asp?si=226&fr=1&sts= [Accessed on 19 January 2008]

Haack, R.A., Petrice, T.R., Wiedenhoeft, A.C. (2010). Incidence of bark and wood boring insect in fire woods: A survey at Michigan's Mackinac Bridge. *Journal of Economic Entomology* 103:1683-1692.

ISPM, (2010). International Standards for Phytosanitary Measures No. 05 2010, Glossary of phytosanitary terms.

Nair, K.S.S. (2007). Tropical forest insect pests: ecology, impact and management. Cambridge. www.Cambridge.org/9780521873321 [Accessed on 9 July 2015]

Ren, Y., Brien G.O., and Desmarchelier J.M. (1997). Improved methodology for studying diffusion, sorption and desorption in timber fumigation. *Journal of Stored Product Resources* 33: 199-208.

Robert, O.O. (2012). Preservation of forest trees against pests and insects attack. *Nigeria International Journal of Modern Botany*, 2 (4): 92-96. DOI: 10.5923/j.ijmb.20120204.05

Rosenberger, R. S. and Smith, E. L. (1997). Non market economic impacts of forest insect pests: a literature review. Gen. Tech. Rep. PSW-GTR-164-ww. Albany, CA: Pacific.

Suitability of *Aningeria robusta* Wood for the Manufacturing of Talking Drum

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ABSTRACT

Some wood are acoustic in nature and has the ability to produce sound effect. Hence, it is a unique material for musical instruments and other acoustic applications. Poor wood quality affects sound generated from talking drum manufactured from wood; hence, the need to examine wood quality in relation to acoustic properties. This study was designed to determine the suitability of Aningeria robusta wood for the manufacturing of talking drum. Three trees of A. robusta were obtained from Gambari Forest Reserve. From each tree, three bolts of 100cm in length were obtained from base, middle and top of the tree. This was later cut into 50cm bolts each for the determination of selected properties and construction of talking drum. From the first bolt, moisture content (MC), wood basic density (WBD), modulus of elasticity (MOE), modulus of rupture (MOR) were determined following standard procedures of ASTM and BSI. Acoustic properties of the manufactured talking drum were determined and sound generated for 8 seconds was recorded in a studio. A spectrum analyzer was used to analyse the sound at three pitch levels (low, medium, high). A complete randomized block design was used and data obtained were analysed using descriptive statistics, ANOVA, correlation analyses at $\alpha_{0.05}$*. The mean MC, WBD, MOE, MOR and impedance for A. robusta were 55.54±2.98%, 429.34±18.91 Kg/m^3, 5876.89±382.82 N/mm^2, 123.91±4.74 N/mm^2, and 1569606±47071.33 kg/m^{2}s respectively. Mean sound frequency, wavelength and speed of sound were 149.22±18.95Hz, 38.84±3.97m, 3711.46±163.99m/s, 3491.97m/s, 1522501kg/m^{2}s respectively. Sound frequency and wavelength were significant at pitch levels. WBD and MOE explained 74% and 88% of the correlation variation observed in the speed of sound from the talking drum respectively. Lower WBD, higher MOE and impedance of A. robusta wood proves a good relationship for achieving suitability in the manufactured talking drum.*

Keywords: Wood basic density, acoustic properties of wood, wood mechanical properties, *Anningeria robusta*,

INTRODUCTION

Some wood are acoustic in nature and has the ability to produce sound effect. Because of this unique property, wood is used in producing a number of musical instruments such as guitar, violin, piano, xylophone and percussion. The talking drum is an example of a percussion instrument; it is an hourglass-shaped drum from West Africa, whose pitch can be regulated to mimic the tone and prosody of human speech when being played by a beater/drummer (Wikipedia, 2009). The pitch of sound produced depends on the frequency of vibration, which is affected by the dimensions, density, moisture content, and modulus of elasticity of the wood. Smaller dimensions, lower moisture content, and higher density and elasticity produce sounds of higher pitch. (Tsoumis, 1991).

Social survey done by Aiyeloja *et.,* (2015) showed that *Cordia millenii* has been the preferred choice to manufacture talking drums in Nigeria, and this was based on the inherited indigenous knowledge as it has been the standard drum making wood species for many years without any effort of domestication. In the meantime, the species became scarce due to multiple uses by the carving and other wood based industries. Consequently, the shortage of this species has forced the carving industry to employ many unsuitable species for talking drum manufacturing which eventually render unsatisfactory services to users. The unsuitability of these species may be greatly due to the poor wood quality relationship with the respective acoustic properties of these species. However, there is increase in the population and advancement in African music today due to the utilization of talking drums, which has immensely increased the popularity of Nigerian culture and entertainment industry beyond Nigeria shore (Agun, 2014). Meanwhile, Albert *et al.,* (2002) stated that acoustic property of wood is a function of modulus of elasticity and density. Also, Iris (2012) reported that acoustic properties rely greatly on the density of the species used. There is therefore urgent need to research into lesser known wood species for the manufacture of African musical instrument, taken into consideration selected physico-mechanical variation along the bole. Research into lesser known wood species like *Aningeria*

robusta wood from Nigeria, to determine its suitability for the manufacturing of talking drum will not only help to reduce pressure on the popularly demand and scarce species but also contribute to the social, cultural and economic lifestyle of the populace.
The aim of this research study was to determine the existing relationship between selected physico-mechanical properties and acoustic properties of *Aningeria robusta* wood with the view of exploring its suitability for the manufacturing of talking drum.

MATERIALS AND METHOD

The materials used for the experiment were goat skin, tension rope (osan), carving tools, microphone, computer system, spectrum analyzer, oven, weighing balance, universal testing machine, and wood samples of *Aningeria robusta.*

Sample Collection and Preparation

Three trees of *Aningeria robusta* with at least 25cm DBH obtained from Gambari Forest Reserve were selected. From each tree, bolt of 50cm in length was collected at the base, middle and top portion to determine the physical and mechanical properties of the wood species as well as for the manufacture of the talking drums. The wood samples was processed using circular machine and planning machine to a dimension of 20x20x300mm for modulus of elasticity and modulus of rupture (mechanical property), 20x20x60mm for wood density and moisture content according to ASTM, 1991.

Determination of Moisture Content

The samples were weighed when wet (original weight), it was then dried to a constant weight at 103^{o}c ± 2 in an oven for 24 hours, after which it was re-weighed. The loss of weight of the wood samples on drying to a constant weight was noted. Calculation of the loss in weight as a percentage of the samples weight after drying was done by using the formula below

$$MC = \frac{ww - ow}{ow} \times 100 \quad \text{..... 1}$$

MC = Moisture Content *ww* = wet weight *ow* = oven dry weight

Determination of Wood Density

The 20x20x60mm wood samples collected were oven dried to a constant weight at 103^{o}C ± 2 for 24 hours and the weight afterward was recorded. The volume of samples at green weight was recorded and the following formula was adopted for the calculation of wood density.

$$D = \frac{m}{v}(kg/m^3) \quad \text{.....2}$$

D = Density *m* = oven-dried mass *v* = green volume

Determination of Modulus of Rupture (MOR)

This involved the use of standard test specimen (10 x 10 x 300mm), in a universal testing machine. The test sample was prepared in such a way that growth rings were made parallel to one edge. From the graph generated by the universal testing machine, the peak and breaking force were recorded; hence "MOR" was calculated as thus;

$$MOR = \frac{3PL}{2bd^2}(N/mm^2) \quad \text{..... 3}$$

MOR = modulus of rupture *P* = load needed for failure *L* = span of the material between support (length)
b = width of the material *d* = thickness of the material

Determination of Modulus of Elasticity

Graph generated from universal testing machine was also used to obtain the force needed to reach elastic limit and its displacement. The modulus of elasticity was calculated from these values. Thus, $MOE = \frac{PL^3}{4\Delta bd^3}(N/mm^2)$ ----------

----------4

Where:

P = load in Newton (N) L = span / length (mm) B = width (mm)
D = depth (mm) Δ = the displacement at beam centre at proportional load

Acoustic Test

The talking drums produced were taking to the musical studio of the Polytechnic, Ibadan, Nigeria for testing. Several strikes of low, medium and high pitch were made on the talking drum by a professional talking drummer, while sounds generated and time taken were recorded, after which it was analyzed using spectrum analyzer to obtain its sound frequencies. Also, talking drum made from *C.millenii* was sourced and acoustic test made for comparison purpose. Other necessary information needed for *C. millenii* was sourced from literature.

Determination of Wavelength

$$\lambda = \frac{v}{f}(m) \quad \text{..... 5}$$

Where: v = velocity f = frequency λ = wavelength (Newtons equation – Wegst, 2006)

Determination of Speed / Velocity of Sound

$$c = \sqrt{\frac{E}{\rho}} \quad \text{..... 6}$$

Where c = speed of sound E = modulus of elasticity ρ = density

Determination of Impedance

$$z = c\rho$$ (Wegst, 2006)..... 7

Experimental Design

The design was of three treatments (top, middle and base) with three replicates in a completely randomized block design and significance differences were tested at 5% probability level. The variables were analysed using descriptive and correlation statistics.

$$Yij = \mu + Ti + Bj + Eij \ldots\ldots\ldots\ldots \quad 8$$

Yij = Observation μ = Mean Ti = Treatment effect (sampling height)
Bj = Block effect (pitch levels) Eij = Error term

RESULTS AND DISCUSSION

Physico-Mechanical Properties

Table 1 shows the mean value of selected properties at different sampling height and among trees.

Moisture Content

The base wood of tree 1 had the highest moisture content of (65.88%) and lowest moisture content (48.44%) was obtained at the middle wood of tree 2. The moisture content for *A. robusta* was (55.54±2.98%)

Wood Density

Mean wood density at the middle wood of tree 1 was lowest (361.67kg/m^3) and highest at the middle wood of tree 2 (517.67 kg/m^3). The wood density for *A. robusta* was (429.34±18.91kg/m^3).

MOE and MOR

Middle wood of tree 3 had the highest modulus of rupture (145N/mm^2) and lowest MOR at the middle wood of tree 1 (95.04N/mm^2). The MOR for *A. robusta* was (123.91±4.74N/mm^2) while the mean modulus of elasticity at the base wood of tree 3 (7008.62N/mm^2) had the

highest modulus of elasticity value and lowest at the base wood of tree 2 (3176.22N/mm^2). The MOE for *A. robusta* was (5876.89±382.82N/mm^2). There was no significance difference of the physico-mechanical properties along the sampling heights.

Table 1: Mean values of physico-mechanical properties determined for *A. robusta*

	TREE 1	**TREE 2**	**TREE 3**	**MEAN**
MC (%)				
TOP	58.02	62.65	65.12	**61.93±2.08**
MIDDLE	38.79	48.44	57.65	**48.29±5.44**
BASE	65.88	48.49	54.77	**56.38±5.08**
MEAN	**513±8.04**	**53.19±4.72**	**59.18±3.08**	**55.54±2.98**
WOOD DENSITY				
TOP	380.42	407.5	434.50	**407.47±15.61**
MIDDLE	361.67	517.67	452.92	**444.08±45.24**
BASE	412.25	515.25	381.92	**436.472±40.35**
MEAN	**384.77±14.76**	**480.14±36.32**	**423.11±21.2**	**429.34±18.91**
MOR*				
TOP	122.1	129.51	129.56	**127.06±2.47**
MIDDLE	95.04	116.33	145	**118.79±14.47**
BASE	116.73	136.87	124.08	**125.893±5.88**
MEAN	**111.29±8.27**	**127.57±6.0**	**132.88±6.26**	**123.91±4.74**
MOE**				
TOP	5807.8	6435.92	6609.44	**6284.39±243.50**
MIDDLE	5754.87	5576.14	5660.49	**5663.83±51.62**
BASE	6862.52	3176.22	7008.62	**5682.45±1253.82**
MEAN	**6141.73±360**	**5062.76±975**	**6426.18±399.81**	**5876.89±382.82**

*MOR = Modulus of rupture, **MOE = modulus of elasticity

Acoustic Properties

Sound frequency and Wavelength

Table 2 shows the mean sound frequency with respect to pitch obtained from the talking drum produced from top, middle and base of *A. robusta* species. The middle wood produced the highest frequency (331±86.31Hz) at the highest pitch while the lowest frequency (50±11.26Hz) was obtained from base wood at the lowest pitch. The mean frequency of sound at top, middle and base tree is thus; (126.67Hz), (186.89), (134.11) compared to *C.millenii* (133). Also, it shows the wavelength of sound with respect to pitch obtained from the talking drum produced from top, middle and base of *A. robusta* species. The base wood had the highest wavelength (84.83±27.78m) at the lowest pitch and the least wavelength (13.07±4.54m) obtained was at the middle wood of highest pitch. The wavelength of sound of the talking drum is thus; (38.84±3.97m).

Speed of sound and Impedance

Table 3 shows the calculated speed of sound in the talking drum produced at different sampling height and for each tree. Speed of sound was highest at the middle wood of tree 3 (4363.87m/s), and it was lowest at the base wood of tree 2 (2482.82m/s) of the talking drum. The mean speed of sound in *A. robusta* was (3711.46±183.35m/s) which performed better compared to *C. millenii* (3491.47m/s), while the talking drum from the middle wood of tree 2 had the highest impedance (1,698,992kg/m^{2}s) and lowest at the base wood of tree 2 (1279273kg/m^{2}s) of the talking drum. The mean impedance for *A. robusta* was (1,569,606±47071.33kg/m^{2}s) compared to *C.mellinii* at (1522501).

There was significant difference between sound frequency produced and the three levels of pitch as well as sound wavelength and the three levels of pitch (low, medium and high pitch) but no significant difference between the sound frequency, wavelength and sampling height.

Table 2: Variation in sound frequency (Hz) and sound wavelength with pitch levels in talking drum between sampling heights of *A. robusta*

	LOW PITCH	MEDIUM PITCH	HIGH PITCH	MEAN
TOP	80.67	129.67	169.33	126.67
MIDDLE	63.67	166	331	186.89
BASE	50	106.67	245.67	134.11
C. millenii	27	153	219	133
Sound wavelength				
TOP	49.99	32.12	23.48	35.19
MIDDLE	68.97	21.73	13.07	34.56
BASE	84.84	35.99	19.52	46.78

Table 3: Speed of sound (m/s) and acoustic impedance (kg/m^{2}s) determined for *A. robusta*

	TREE 1	TREE 2	TREE 3	MEAN	*C. millenii*
SPEED					
TOP	3907.29	3974.12	3900.2	**3927.2±23.54**	**3491.47**
MIDDLE	3988.99	3282.02	4363.87	**3591.63±208.74**	**3491.47**
BASE	4080.01	2482.82	4283.83	**3615.55±569.41**	**3491.47**
MEAN	**3992.1±49.88**	**3246.32±430.87**	**3895.97±225.16**	**3711.46±183.35**	**3491.47**
Impedance					
TOP	1486398	1619454	1694637	**1600163±60882.23**	**1522501**
MIDDLE	1442685	1698992	1586961	**1576213±74184.56**	**1522501**
BASE	1681984	1279273	1636066	**1532441±127276.2**	**1522501**
MEAN	**1537022±73171**	**1532573±128714**	**1639221±31123**	**1569606±47017**	**1522501**

Relationships Between Selected Physico-Mechanical Properties and Acoustic Properties

Table 4 shows the respective correlation between the speed of sound and the selected physico-mechanical properties determined. It thus shows an existing association of -86% and 94% for wood density and modulus of elasticity respectively. It also shows that the respective correlation between the frequency of sound and wavelength (at high, medium and low pitch) with wood density, moisture content, modulus of rupture (MOR), modulus of elasticity (MOE), impedance, had an average to lower existing association of correlation.
However, in Table 5 there was an existing high degree of association of -92%, -83% and -85% between frequency and wavelength at corresponding pitches.

Table 4: Correlation analysis between selected acoustic and physico-mechanical properties.

	Speed (m/s)	F (Hz) at High Pitch	F (Hz) at Medium Pitch	F (Hz) at Low Pitch	λ (m) at High Pitch	λ (m) at Medium Pitch	λ (m) at Low Pitch	Impedance
Wood density	-0.861	0.294	0.025	-0.309	-0.581	-0.440	0.074	-0.093
MC	0.359	0.202	-0.271	-0.023	0.027	0.339	0.181	0.568
MOR	-0.406	0.189	-0.147	0.298	-0.174	-0.014	-0.378	-0.023
Impedance	0.583	0.302	-0.135	-0.507	0.061	0.403	0.647	1
MOE**	0.938	0.049	-0.192	-0.249	0.407	0.621	0.478	0.823

MOR* – Modulus of rupture MOE** – Modulus of elasticity

Table 5: Correlation analysis between frequency and wavelength of sound

	F(Hz) at low pitch	F(Hz) at medium pitch	F(Hz) at high pitch
λ(m) at low pitch	-0.927		
λ(m) at medium pitch		-0.837	
λ(m) at high pitch			-0.851

F – Frequency, λ - wavelength

DISCUSSION

Frequency and Wavelength

Frequency is a function of its source(s) of propagation (PSE, 2015). It therefore cannot change as a result of the medium's (wood) properties it passes through, unless there is a new source of propagation within the medium it is passing. The stated above clearly explained the reason why correlation analysis done on physico-mechanical properties to frequency in table 4 had an average to low degree of association. This therefore means that the frequency and Wavelength generated by the talking drum produced from top, middle and base wood of *A. robusta* does not depend on the individual physico-mechanical properties of wood used, rather it may be dependent on sources of propagation such as, the force of strike, tension rope, and skin cover of the talking drum amongst others. The findings of this work on the resulting frequency supports Doppler's effect (Alec, 1992), Wien (1992) as reported by Wikipedia, (2015) but contradict Ferry (1980), Olagunade (2009), and Noah *et al.,* (2012), who reported that frequency tend to increase with MOE and wood density.
From Doppler's effect, it can therefore be said that frequency will depend on distance (i.e. wavelength of the sound), at a constant speed. Hence, correlation analysis done for frequency and wavelength in table 5 to test for relationship between them showed an inversely proportionality with degree of association of 92%, 83% and 85% at low, medium and high pitch respectively. It can then be concluded that frequency tends to increase with decreasing wavelength while wavelength of a sound obtained in a wood depends on the velocity and frequency of the sound and not necessarily on the wood properties; thus; supports Newton's law.

Speed of Sound

The relationship between speed of sound and wood density of *A. robusta* shows that the more the wood density, the lesser the speed of sound in the wood, and the probability of its occurrence was high at 86%. This finding is against Shander (2015), Adrian (2015), Paul (2015); they all argued that since sound wave needs a medium to propagate, and this propagation depends on how closely the particles are together in the solid (i.e. density), then it is expected that sound wave will cover a longer distance in shortest time possible with denser medium. Nevertheless, the above research findings was supported by NDT (2015), which noted that a denser medium can transmit sound slower if the medium is denser as a result of larger molecules in it. Hence lower speed of sound in the medium.
In addition, sound waves are made up of kinetic energy and it takes more energy to make large molecules vibrate than it does to make smaller molecules vibrate. Thus; sound will travel at a slower rate in the more dense material if the material is made up of larger molecules. According to Integrated Publishing (2015) on acoustic of sound quality, it highlighted that a denser material may pass sound slower, and this also supports the findings of this study. Therefore, the resulting lower speed value of the talking drum at the middle wood (densest) of *A. robusta* may be due to existing larger molecules in the middle wood which may be attributed to a thicker cell wall. In Table 4, MOE had a high degree of association at 94% with speed of sound, this indicated a high probability of occurrence between speed of sound and modulus of elasticity, which shows that the more the elasticity of a wood, the more the speed of sound in the wood. It can therefore be concluded from Table 4 that only wood density and modulus of elasticity had a strong degree of association with speed of sound while other properties have individual lower correlation with speed of sound from talking drum manufactured from *A. robusta*.

Impedance

The decreased impedance value from positive (+) to negative (-) in degree of association from high pitch to low pitch of sound implies that impedance reflect sound of higher pitch than sound of lower pitch, and when high level of reflection occur it will either result in constructive or destructive interference of wave, given rise to high intensity (Richard, 2015). Hence, louder sound will be generated. Of all the physico-mechanical properties tested, only MOE has a high positive correlation with acoustic impedance at 82% degree of association. This implies that a wood with more MOE will produce better acoustic impedance. It can therefore be concluded that the top wood with highest impedance was more suitable.

CONCLUSION

Contrary to the opinion reported in many publications that frequency and wavelength of a sound at any time and condition depend on the medium in which the sound passes through, this research work on talking drum produced from *A. robusta* has recorded an interspersing trend in the relationship of the determination of frequency and wavelength through its medium (wood), which later shows that frequency and wavelength of sound in talking drum depends only on source(s) of propagation and not the wood, unless there is another source of sound propagation in the wood. Of all the wood properties lower wood density and corresponding higher MOE and impedance are the wood traits to be considered for suitable acoustic performance of wood in the manufacturing of talking drum.

RECOMMENDATION

A. robusta is therefore, recommended for manufacturing talking drum. It is a better substitute for already pressured *C.mellinii* as it performed better.The top wood of *A. robusta* is considered most suitable.

REFERENCES

Adrian, S. (2015): Why does sound travel faster in a denser medium whereas light travels slower? UCLA in physics. physicslink.com/education/askexpert/ae81.cfm

Agun, F. (2014): The talking drum –Kalangu, Gangan, Odondo drum. Article retrieved from http://tony55.hubpages.com/hub/The-Talking-Drum-The-Talking-Drum-Kalangu-Gungun-Odondo-drum.

Aiyeloja, A. A. Adedeji, G. A. and Adebisi L. A. (2015): Suitability of *G*. arborea (Roxb.) wood for making talking drum in Nigeria. IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS). *Volume* 8, Issue 2 Ver. II PP 95-100.

Albert, D.J. Clare, T.A. Dickson, R.L. and Walker, J.C.F. (2002): International Forest review 4(1) Pp. 12-16.

Alec, E. (1992): The search for Christian Doppler, Contains a facsimile edition with an English translation.Retrieved from Wikipedia (2015).

American Society for Testing and Materials (ASTM, 1991): Standard test methods for specific gravity of wood and wood-based materials D2395-02. Annual Book of ASTM Standards. Section 4. Volume 04.10. West Conshohocken, PA. USA: 844 p.

Ferry, J.D, (1980); Viscoelastic properties of polymers, 3rd edition, Ney York, wiley

Integrated publishing, Inc. (2015): acoustic: sound quality; module 10, introduction to sound propagation, transmission lines and antennae. P. 43

Iris, B. (2012): Acoustical properties of wood in string instruments soundboards and tuned idiophones: Biological and cultural diversity. Journal of the Acoustical Society of America, 131(1):807-818.

Noah, A. S. Abiola, J. K. Ayeni, O. D. and Bamidele, O. D (2012): Comparative Assessment of selected Acoustic Properties of Talking Drums Made from Wood of *Gmelina arborea* (Roxb) and *Brachystegia eurycoma* (Harms); Journal of Multidisciplinary Engineering Science and Technology (JMEST) Vol. 1 Issue 5, pg 22-27

NDT - Non Destructive Testing Education Resource Center (2015): Acoustic impedance. The Collaboration for NDT Education, Iowa State University, www.ndt-ed.org.

Olagunade, A.Z. (2009): Determination of acoustic properties of talking drum using three wood species.unpublished

Paul Walorski (2015): Why does sound travel faster in a denser medium whereas light travels slower? UCLA in physics A.B. Physics physicslink.com/education/askexpert/ae81.cfm

PSE (Physics stack exchange) (2015): independence of frequency in sound wave. 2015 stack exchange Inc. www. Physics.stackexchange.com

Richard, E. B. (2015): physics; sound. *©2015 Encyclopædia Britannica, Inc.*

Shandar, A. (2015). Why does sound travel faster in a denser medium whereas light travels slower? UCLA in physics physicslink.com/education/askexpert/ae81.cfm

Tsoumis, G. (1991): Science and Technology of Wood- Structure, Properties, Utilization. New York: Van Nostrand Reinhold.

Wegst, U.G.K. (2006): Wood for sound; American journal of botany. Vol 93. Pp. 1439-1441

Wikipedia (2009): Talking drum

Synthesis and Performance of Pyrolysis-Oil phenol Formaldehyde Adhesive from *pinus caribaea (morelet)* as Particle Board Binder

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ABSTRACT

This study explored the synthesis and performance of pyrolysis-oil phenol formaldehyde adhesive (PPF) from Pinus caribaea bark as particle board binder. Phenol from commercial phenol-formaldehyde (PF) adhesive used as composites board binders for exterior purposes was replaced with the Phenolic components obtained from the pyrolysis of P.caribaea bark (bio-mass) that is heating it at temperature of 600^0 C in the absence of air or oxygen to obtain a dark reddish liquid known as pyrolysis oil (PO) or Bio-oil through condensation and subsequent fractionating and separation into phenolic components. The liquid was successfully applied to synthesize pyrolysis-oil phenol formaldehyde (PPF) resins up to 100% by weight substitution for phenol. The synthesized PPF was used as a binder for the production of laboratory scale particle board. The dimensions of the boards were 200 mm by 200 mm by 10 mm; twenty five panels were produced in all. The result of the physical properties of the formulated PPF resin shows little differences in properties such as viscosity, pH value, non-volatile contents, among the 5 resins prepared in the study with exception of gel time(s). Physical and mechanical properties (Dry IB, WA, TS) of the produced panels were conducted and result was subjected to analysis of variance in a one-way completely Randomized Design and Least Significant Difference Test (LSD) to compare their means. Panels bonded with resins having 50% by weight of PPF yielded the highest dry IB and attained one of the best water absorption and thickness swelling; by so doing, exhibited comparable mechanical properties to those of panels made with commercial resin under the same production and pressing conditions.

Keywords: Adhesive, pyrolysis-oil- Phenol formaldehyde (PPF), Synthesis, *Pinus caribaea* bark, Particle board.

INTRODUCTION

Wood composites describe a unique group of materials that combine two or more physically different materials with the aim of achieving enhanced properties that cannot be attained when each material is used individually. Wood is the primary raw material used, and the bond necessary to hold them together is produced by an adhesive. Worldwide, there has been growing concerns about ways to efficiently utilize forest trees, residues and underutilized tree species. Efficient utilization of these resources will reduce the burden of overdependence on conventional trees species used for lumber and structural applications.

Bark, a nonfood related biomass material available in large quantities, is a residue from forest operation and mills. Compared with wood, bark has a similar chemical composition but contains more extractives and phenolic compounds. Bark and bark phenolic compounds have been used to partially substitute petroleum-based phenol in resin synthesis Harkin and Rowe, 1971. One of the processes used to convert biomass into energy and reusable chemicals is pyrolysis, a thermal decomposition process in the absence of oxygen. Wood charcoal, pyrolysis oils (PO), water and gaseous products are produced during the pyrolysis process. The proportion of these products depends on the process. Fast pyrolysis requires that biomass is rapidly heated at temperatures between 450 and 600^0 C in the absence of air or oxygen. By condensing the organic vapors formed, a dark reddish liquid is obtained known as pyrolysis oil (PO) or Bio-oil.

Phenol-formaldehyde (PF) resins are widely used as adhesives (Alma and Basturk, 2006; Wang *et al*., 2009 ; Amen-Chen, *et al.*, 2002) in the wood products industry for the manufacture of plywood, oriented strand board (OSB), particleboard, fiberboard, other composite products, and molded products (Alma, 1996, 1997; Shiraishi *et al.*, 1993) because of its high strength and moisture resistance. Phenol as

the most costly chemical raw material for the synthesis of PF resins is primarily produced from petroleum-derived benzene by the cumene process developed by Hock and Lang, 1944. Depleting petroleum resources combined with increasing demands for petroleum by developing economies, as well as political and environmental concerns over fossil-based resources has intensified the interest in researching and developing alternative renewable resources for both energy and chemical production. Biomass is the only sustainable source of organic carbon that provides approximately 14% of the world's energy needs, representing an alternative, and renewable, source of both bio-fuels and valuable chemical compounds. This has necessitated this study whose broad objective was to obtain pyrolysis-oil phenol formaldehyde (PPF) adhesives from the bark of *Pinus caribaea* and modify the oil at different formulation percentages and to determine its effectiveness as particle board binder.

MATERIALS AND METHOD

The materials and laboratory apparatus used in the research work were *Pinus caribaea* barks, *Gmelina arborea*, sawdust, Rice husk. The chemicals used are: sodium hydroxide NaOH, Ammonium chloride NH_4Cl, glycerol, Methanol, phenol formaldehyde, commercial phenol, formalin. Laboratory equipments/machineries used are: digital weighing-machine, caliper, INSTRON Machine, The pyrolytic unit, fabricated hot press with temperature, pressure and time control.

Pinus caribaea bark source and preparation

Pinus caribaea bark was obtained from the pine tree plantation established by Forestry Research Institute of Nigeria (FRIN). Based on the report obtained from the records department; the age of the plantation was 17years when established. After procurement the bark was sun-dried for two weeks and crushed manually to about not less than 6 cm length

Production of pyrolytic oil from *Pinus caribaea* bark

The pyrolytic unit used for this study was fabricated by Titiladunayo (2011) of the Department of Mechanical Engineering; Federal University of Technology Akure, It was used for PhD study titled "Development of a biomass pyrolysis reactor and characterisation of its product for industrial application".

Synthesis of bio-based adhesive from pyrolytic oil

Synthesis of the bio-based adhesive was carried out by loading 294.12 g of phenol and 588.24 g of formaldehyde (from formalin) into a 500 ml round bottom flask equipped with refluxing condenser. The content of the flask was homogenized for about 15min using a magnetic stirrer. The flask was immersed in a glycerol oil bath. The temperature of the oil bath was maintained at 800 C. 117.65 g of 50 % NaOH (w/w) was added at 15 min interval. Following each addition of sodium hydroxide the temperature was decreased by a 10° C . The reaction was terminated by rapidly cooling the mixture to 25° C after 90 minutes. The experiment was repeated for 25 %, 50 %, 75 % and 100 % phenol replacement. The weight in gramme of Formaldehyde, Phenol and Sodium Hydroxide at each percentage level of oil- phenol replacement were calculated by the formula. The resin used as the control was a commercial 13BO33 Liquid Phenol Formaldehyde (PF) solution purchased from Sigma- Aldrich Chemicals, Inc., USA

$$\boldsymbol{Mixing\ Ratio} = \boldsymbol{A} \times \frac{\boldsymbol{F}}{\boldsymbol{F+P+NaOH}}$$ (Gardziella *et al*, 2000).

Where: **A** is the formulation in 1000 ml standard solution, **F** is Formaldehyde, **P** is Phenol and **NaOH** is Sodium Hydroxide. The addition of formaldehyde, phenol and Sodium hydroxide (that is **F** + **P** + **NaOH**) is in the ratio of **2: 1: 0.4**
The weight in gramme calculated for each ingredient was used in the formulation of 1000 ml solution (Table 1).

Preparation/ production of Experimental wood particleboard

Saw-dust collection and preparation

Gmelina arboraea saw-dust was obtained from Saw mill plant (Bodija, Ibadan). Conscious effort was made to collect the dust during sawing to ensure species were not mixed. The *G .arboraea* sawdust were sun-dried for two weeks, sieved with 2 mm mesh sieve to ensure they are of equal sizes, and kept in polythene bag prior to use for the production of particle boards.

Mould preparation

Square aluminum foil moulds with lid of dimension 200 mm by 200 mm by 10 mm were fabricated for each Resin formulation with the control i.e. 100 %, 75 %, 50 %, 25 % and 0 % (Commercial Resin - Control) oil replacement. Each treatment was replicated 5-times; thus, a total of 25 moulds were made.

Mixing of the ingredient

To prepare each panel of 700 kg/m^3 density using the formula:

$$\textbf{Density}(\textbf{gcm}^3) = \frac{mass\,(g)}{volume(cm^3)}$$

$$\textbf{Volume} = \frac{(200\text{ mm X }200\text{ mm X }10\text{ mm})}{1{,}000} = 400\text{ cm}^3$$

$$0.70 = \frac{\text{mass}}{400}$$

Therefore, Mass = 280 g.

Two hundred and eighty grams (280 g) by weight of the sawdust were further oven dried to obtain the weight on oven-dried basis; which was 266.6grammes. The resin used was calculated based on the oven-dried weight of the sawdust (10% by weight of the saw-dust) other additives were Rice husk (Extender) 10% of the weight of the oil, Ammonium chloride, NH_4Cl (Hardener) 2% of the weight of the oil, Water 0.4% of the weight of the oil. These additives together with the saw-dust (weighed on oven-dried basis); were blended together thoroughly in mixing container to ascertain even distribution of adhesive on the particles. After blending, the randomly oriented sawdust was carefully felted into the 200 mm x 200 mm by 10 mm mould to form the mat. The all-round homogenously produced boards were hot pressed one after the other at temperature of 600 ^{0}C and pressure of 18 psi. Press time was 2 minutes. (The hot press used in this case was self-fabricated). After the board has been pressed and cured, they were removed from the press, demoulded, conditioned and trimmed to remove excess dimensions. Similar method was used to produce all the boards for the study.

Determination of board physical properties

Water Absorption

(ANSI/A208.1, 1999) procedure was used to for sample measurement. The final weight of the boards was also recorded after 24 hours of soaking in water and it was allowed to dry.

Water absorption was calculated using the formula:

$$(\text{W.A.}\,\%) = \frac{(W_2 - W_1)}{W_1} \times \frac{100}{1}$$

Where: W_1 = Initial weight (g)
W_2 = Final weight (g)

The same procedure was repeated for the commercial PF Resin panels, after which the result was compared to ascertain the performance of the formulation.

Thickness Swelling

(ANSI/A208.1, 1999) procedure was used to for sample measurement. The final thickness of the board was recorded after 72hrs of soaking in water and it was allowed to dry. Thickness swelling was calculated using the formula

$$T.S.\,(\%) = \frac{T_2 - T_1}{T_1} \times \frac{100}{1}$$

Where T_1 = Initial thickness (mm) and
T_2 = Final thickness (mm)

The same procedure was repeated for the commercial PF Resin panels, after which the result was compared to ascertain the performance of the formulation.

Mechanical Properties

Internal Bonding Strength

It was determined using three conditioned specimens of 50 mm x 50 mm from each particleboard. Each panel was cut to width of 50mm, thickness 4mm, and length of 50mm for Internal bonding in line with INSTRON 3369. The length grip of the machine with the material is at a distance of 10mm.The readings for the mechanical properties on the appendix page was taken at every micro-second. The experimental design adopted was analysis of variance in a one-way completely Randomized Design experiment. Follow-up test was conducted with the use of Least Significant Difference Test (LSD). This was done to compare the mean.

RESULTS AND DISCUSSION

Table 1: Formulation in 1000ml Standard Solution (A)

	Replacement by weight (g)				
	0 % PPF	**25 % PPF**	**50 % PPF**	**75 % PPF**	**100 % PPF**
Comm. Phenol (P)	294.12	220.59	147.06	73.53	0.00
Bio-Oil	0.00	73.53	147.06	220.59	294.12
Formaldehyde (F)	588.24	588.24	588.24	588.24	588.24
NaOH	117.65	117.65	117.65	117.65	117.65

Physical properties of resin adhesives

From Table 2 above, physical properties of the formulated oil-formaldehyde resin shows that, the resin properties, with exception of gel time, showed little difference among the 5 resins prepared in the study. Solid content ranged from 51.10 percent to 51.70 percent, and pH ranged from 11.10 to 12.81.The resin viscosity ranged from 340 to 470 cps. This falls in line with the targeted viscosity of 300 to 450 cps in resin synthesis (ASTM D1084 – 08). In general, the viscosity was comparable with that of the commercial PF resins. The most interesting result in the study of resin properties was gel time. The gel time for oil-formaldehyde resins ranges from 48.20 to 56.3 seconds and were substantially longer than the gel time of PF resin which was 22.1, this could be attributed to the curing kinetics of phenol formaldehyde resin and wood-resin interactions in the presence of wood substrates (He & Reidl, 2004). The presence of water in my own formulation also attributes to the long curing time of the formulated resin as water plays an important role during cure. For instance, it has been reported that at 100^0C, the curing rate of aqueous adhesives such as PF decreases with increasing moisture. This was explained by the fact that the extra water acts as an energy barrier to cross linking Chow and Hancock, (1969); Chow and Mukai, (1972). This is due to the fact that moisture improves the flow ability of the compounds by plasticization (Tonogai *et al*, 1978; Tonogai *et al*., 1980, Wang & Reidl, 1995). When compared with the property of the commercial PF resins included in the study as controls, the oil-formaldehyde resin had lower solid content, but higher resin pH, gelation time and viscosity.

Table 2: Physical properties of resin adhesives

Resin Properties	**Control**	**PF with 25% PPF Subt**	**PF with 50% PPF Subt**	**PF with 75% PPF Subt**	**100 % PPF**
pH, 25^{o}C	11.10	12.81	12.68	12.61	12.64
Gel time, s	22.10	49.20	48.20	55.60	56.30
Viscosity, cP	340.00	460.00	470.00	420.00	400.00
Solid, %	55.00	51.70	51.50	51.20	51.10

Control: Commercial Phenol Formaldehyde (**CPF**), **PF**: Phenol formaldehyde, **Subt:** Substitution,

The mean of the dry Internal bonding strength (Mp_a), Water absorption 72hrs (%) and Thickness swelling 72hrs (%)

The result of the physical and mechanical properties of the panels produced from the formulated PPF resin was presented in Table 3. The board density was 700Kg/m^3. The result of the Internal bonding strength in Table 3 revealed that 50 % PPF resin behaves in almost the same manner as the commercial which has internal bonding strength of 2.59, followed by 25 % PPF replacement with the value of 1.98, this is followed by 100 % PPF replacement with value of 1.91. Seventy – five (75) % PPF replacement by weight has the lowest value of 1.01 which is in line with the work of Badamkhand *et al*., (2001) where they isolated pyrolytic lignin and incorporate it into PF resin at 30 %, 40 % and 50 % PF replacement level, and the resultant resin were evaluated as OSB core binder; of which their result indicated that the pyrolytic lignin is effective for up to about 40 % replacement. This also suggest that more intense cross-linking of the adhesive mixture occurred with 50 % PPF resin replacement
Also the result of the analysis of variance and the follow-up test shows that there is significant difference among the adhesives formulations at different percentages, which suggest that the concentration of the adhesives at different formulation percentages has effect on the result obtained.

Also, from Table 3 the mean values obtained for water absorption 72hrs (%) for the PPF formulated at different percentages it was observed that commercial (control) has the highest value of 7.05 followed by 50 % PPF replacement with value of 6.35. Twenty-five (25) % PPF replacement has the next value of 6.01, followed by 75 % PPF replacement with value of 6.00. 100 % PPF replacement has the least value of 5.88. Consequently, analysis of variance conducted reveals that there is significant difference in the water absorption (72hrs) among the formulated adhesives at different percentages, which suggest that concentration of the formulation adhesives at different percentages has effect on the result obtained. . This result may suggest that the hydrophilic nature of some compounds in the pyrolysis oils may be responsible for less water-resistant resins in comparison with the commercial resins. However, these hydrophilic compounds contribute or add cohesiveness to the resin as demonstrated in the dry IB results, which are quite high. It is possible that the hydrophilic compounds are cellulose-derivatives in their monomeric or oligomeric state.

The result of the mean thickness swelling 72hrs (%) in Table 3 also revealed that 50 % PPF replacement has the highest value of 6.01, followed by commercial(control) which has value of 5.77.This is followed by 25 % PPF resin replacement with values of 4.66. Seventy-five (75) % PPF replacement has the least value of 4.53. The result of their analysis of variance reveals that there is significant difference among the adhesives formulated at different percentages that is the concentration of the adhesives at different formulation percentages has effect on the result obtained. It has been reported that higher thickness swelling is related to higher internal bonding of panels (Wu and Piao 1999). Since thickness swelling is the consequence of compression stress relief due to deformation of the mattress, moisture pick-up from the surroundings and from degradation of inter-particle bonding due to the combination of the processing temperature used and resin bonding quality. Chan *et al*. (2001), found that post-treatments like ''hot stacking'' provides improved TS values for PF adhesives substituted with PO at different ratio. The most interesting result in the study was the overall performance of the 50 % PPF resin replacement. It yielded the highest dry IB, attained one of the best water absorption and thickness swelling consequently its ability to savage the cost factor in phenol while maintaining a workable viscosity provide the needed flexibility desired for further research.

The result also suggested that at 50 % PPF replacement level, there is good compatibility of these two chemical which ensure crosslinking between pyrolysis oil oligomers and PF chains to get good resin These preliminary results indicates that homogenous panel could be produced with 50 % PPF replacement at this level, it yielded the highest dry IB, attained one of the best water absorption and thickness swelling when compared with commercial produced under the same condition. Consequently its ability to savage the cost factor in phenol while maintaining a workable viscosity. Bio-oil derived from the pyrolysis of biomass, or its phenolic fraction, has been used with success as phenol substitute in phenol-formaldehyde resin substitute level of up to 40 % have been reported (Amen-Chen *et a*l., 2002).

Table 3: The mean of the dry Internal bonding strength (Mp_a), Water absorption 72hrs (%) and Thickness swelling 72hrs (%).

Density (kg/m^3)	Adhesive Mixing Ratio	Dry IB (Mp_a)	WA 72hrs (%) Mean values ± SD	TS 72hrs (%)
700	CPF (Control)	2.59±0.44	7.05± 0.15	5.77±0.19
	PF with 25% PPF Subt	1.98±0.23	6.00±0.15	5.25±0.40
	PF with 50% PPF Subt	2.50±0.94	6.35 ±0.01	6.01±0.25
	PF with 75% PPF Subt	1.01±0.34	6.01±0.07	5.53±0.41
	100 % PPF	1.9±0.58	5.88 ±0.11	5.66±0.34

CONCLUSION AND RECOMMENDATION

Conclusion

From the result of the study, it was discovered that the PPF adhesives has high viscosity, this will be a disadvantage to the product in terms of ease of handling i.e. transportation and weight of the material.

Recommendation

I would recommend the use of our indigenous wood specie most especially the lesser-known species as Bio-mass for this study, availability of such specie (bio-mass) must be ascertained The PPF must also be standardized by the Standard Organisation of Nigeria (SON). In terms of price, the PPF should be able to compete favorably with the petroleum based product. Other bio-mass should be explored into, most especially our indigenous lesser utilized wood species, this is because viscosity also depends on the kind of feed- stock used.

REFRENCES

Amen-Chen C, Riedl B, Roy C. Softwood bark pyrolysis oil–PF resols–Part 2. Thermal analysis by DSC and TG. Holzforschung. 2002 (a), 56: 273–280.

Amen-Chen C, Riedl B, Wang X, Roy C. Softwood bark vacuum pyrolysis oil–PF resols for bonding OSB Panels. Part III. Use of propylene carbonate as resin cure accelerator. Holzforschung. 2002 (b), 56: 281–288.

Alma MH, Basturk MA, Shiraishi N. Cocondensation of NaOH-catalyzed liquefied wood wastes, phenol, and formaldehyde for the production of resol-type adhesives. Ind Eng Chem Res. 2006, 40: 5036–5039.

Badamkhand Sukhbaatar, Philp H. Steele and Moon G. Kim (2009): Use of Lignin separated from Bio-Oil in Oriented Strand Board Binder Phenol-Formaldehyde resins.*BioResources 4(2) page 789- 804.*

Chan, F.D., Riedl,, B., Wang, X.M., Lu, X., Amen-Chen, C., Roy, C. (2001) Performance of pyrolysis oil-based wood adhesive in OSB. Forest Prod. J. 52:31–38

Chow, S., Steiner, P.R., (1979): Comparisons of the cure of phenol–formaldehyde novolac and resol systems by differential scanning calorimetry. *Journal of Applied Polymer Science* 23, 1973–1985.

Chow, S.Z., Hancock, W.V., (1969): Method for determining degree of cure of phenolic resin. *Forest Products Journal* 19, 21–29.

Chow, S.Z., Mukai, H.N., (1972): Effect of thermal degradation of cellulose on wood-polymer bonding. *Wood Science* 4, 202–208.

Gardziella, A., Pilato, L. & Knop, A., (2000): *Phenolic resins: Chemistry, applications, standardization, safety, and ecology*.(Springer Verlag).

Gu J.Y. (1998): Adhesive and Paint.Beijing: *China Forestry Publishing House. Pg 48-125.* Harkin, J.M. and Rowe, J.W., Bark and its possible uses, Forest Research Note-091, 4056-9 71, Forest Products Laboratory, Forest Service, U.S. Department of Agriculture (1971)

He, G. B.; Riedl, B. (2004): Wood Science Technology, 38, 69.Hock H, Lang S. Ber Dtsch Chem Ges. B77. 1944, p. 257.

Shiraishi N, Kajita H, Norimoto M. Recent research on wood and wood-based materials. Elsevier Applied Science, London and New York.1993, p. 36.

Titiladunayo (2011) *Development of a biomass pyrolysis reactor and characterisation of its product for industrial application*".*Ph.D. thesis* submitted to the Department of Mechanical Engineering; Federal University of Technology Akure,

Tonogai, S., Hasegawa, K., Kondo, H., (1980): Influence of moisture content on curing behavior of two-step phenolic molding compounds. *Polymer Engineering Science* 20, 1132-1137.

Tonogai, S., Sakaguchi, Y., Seto, S., (1978): Curing behavior of two-step phenolics by solvent extraction. *J. Appl. Polymer Science* 22, 3225-3234.

Wang M, Xu C, Leitch M. Liquefaction of cornstalk in hot-compressed phenol–water medium to phenolic feedstock for the synthesis of phenol–formaldehyde resin. Bioresour Technol. 2009 (a), 100: 2305–2307.

Wang, X.M., Riedl, B., Christiansen, A.W., Geimer, R.L., (1995): Differential scanning calorimetry of the effects of temperature and humidity on phenol-formaldehyde resin cure. *Polymer* 35, 5685–5692.

Wu, Q. and C. Piao. (1999): Thickness swelling and its relationship to internal bond strength loss of commercial oriented strandboard. Forest Products J. 49, 50-55

Evaluation of Fibre Characteristics and Chemical Compositions of Maize Cob of Different Particle Sizes for Paper Production

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ABSTRACT

Agricultural waste (maize cobs) was examined as suitable alternative in fibre making for paper production due to the diminishing nature of fibrous woody species used for paper production. Chemical compositions and fibre characteristics with their derived values were evaluated to ascertain their suitability for paper making in paper based industry. Maize cobs were collected, grinded and sieved into (2, 4 and 6mm) particle sizes. Fibre maceration (pulping) was achieved using acetic acid and hydrogen peroxide ratio 30: 70 at 100^{o}C for two hours. Fibre dimensions were examined using Visopan Microscope. Data were analyzed using ANOVA while Duncan Multiple Range Test (DMRT) was used for mean separation. Results indicated that mean fibre lengths, fibre diameter, lumen width, and fibre wall thickness, for 2, 4 and 6mmwere: 0.29, 0.30mm, 21.140, 25.370, 24.460, 11.950, 17.190, 15.790 and 4.600, 4.090 and 4.330µm respectively. Further chemical analysis revealed average values of cellulose 38%, hemicelluloses 29.33% and lignin content 12.67% while the average Runkel ratio for 2, 4 and 6mm were: 0.782, 0.477 and 0.560 respectively. Further results revealed that there was no significant difference between the FL and CWT in 2mm at 5% ($p< 0.05$). While there were significant difference between FD and LW both at 2mm at5% ($p< 0.05$). There were no significant differences in the chemical parameters examined across the three particle sizes and does not show any significant difference within each particle size at 5% ($p< 0.05$) level. Based on the satisfactory level of the parameters investigated, maize cob is a potential alternative in the pulp and paper based industry.

Key words*:* Agricultural waste, maize cob, fibre maceration, chemical composition fibre characteristics

INTRODUCTION

Agricultural wastes are wastes generated in the cause of harvesting and processing of agricultural produce or after consumption which indiscriminate disposal and improper handling may constitute nuisance and cause severe harm to the environment. Meanwhile, some of these wastes could be transformed to useful raw materials and at the same time be recycled for sustainability. Among agricultural wastes, maize cob is worthy of special mention due to its high volume productivity with corn (*Zea mays L.*) being ranked third among the most widely cultivated cereals worldwide after wheat and rice (FAO, 2008). According to Buranello (2009) the worldwide production of corn is around 800 million tons therefore, it is necessary to assign for correct use the waste material produced by this crop. The development of maize processing in the 20th century resulted in an increase in the volumes of this by-product (Lenz, 1948). About 180 kg of cobs are obtained from each tone of maize shelled (Evers *et al*., 1994). In the USA, it was estimated that about 50 million tonnes of cobs were produced annually in the 2000s, most of them being left on the field (Janson, 2012)

Maize cobs are a highly fibrous product with many agricultural and industrial applications.In agriculture, they are used for fuel, litter for poultry and other animals, mulch and soil conditioner, and as fodder for ruminants despite the low nutritive value ((Evers *et al*., 1994; Jansen, 2012). More recently, maize cobs were reported to be a potential cheap and promising source for sustainable energy production (Evers *et al*., 1994; Jansen, 2012). The idea for utilizing maize cob waste from agricultural sectors for primary or secondary fibre source is attractive due to their availability, indigenous and also environmentally friendly. However, Non-wood fibre sources account for about 5–10 percent of global pulp production, for a variety of reasons, including seasonal availability, problems with chemical recovery, brightness of the pulp etc (Market Pulp Association and Judt, 2007) These wastes can therefore be recycled for use hence; most agricultural by-products are composed of cellulose in the plant cell walls and can be processed in the agro-residue based mills as well in the recycle fibre based mill for production of pulp and paper. Agricultural-based paper is a guaranteed way to reduce the stress of paper production on old

growth and endangered forests. Another interesting thing is that some agricultural residue pulps take less time to cook than wood pulps. Likewise, agricultural-based paper uses less energy, less water and fewer chemicals. Therefore, pulp which is a lignocellulose fibrous material prepared by chemically or mechanically separating cellulose fibres from wood is an eye opening to the idea of utilizing other agricultural residue or waste that are fibre based in nature aside from wood for fibre making for paper production to reduce pressure on the forest estate and at the same time serve as means of converting waste to wealth. In the context of this research, emphasis is on maize cob and its potential in fibre making for pulp and paper production.

MATERIALS AND METHODS

Collection of raw material and particle processing

Maize cobs were sourced from the farm land of the Directorate of University Farm (DUFARM) and maize shelling unit of the processing farm all in the Federal University of Agriculture, Abeokuta. Collected maize cobs were sundried, de-pithed, mealed and further separated into different particle sizes (2, 4 and 6mm).

Fibre maceration and measurement

Modified Franklin method (Hen *et al.* 1999) was adopted where 5g of granulated maize cob were subjected to maceration (chemical pulping) using glacial acetic acid (CH_3COOH) and hydrogen peroxide (H_2O_2) were mixed at ratio 30:70 at 100^oC for two hours in a fume cupboard for complete digestion. The mixtures (slurry) obtained after digestion were thoroughly washed with distil water to remove the chemicals and all other components of the slurry leaving only the mat of fibre for measurement.

Fibre dimensions were examined using Visopan Microscope. Bias of selecting only longer fibre was eliminated by using the procedure of Andrew and Prentis (1979). Twenty fibres were measured for the purpose of determining fibre length (L), fibre diameter (D), Lumen width (d), Cell wall thichness (cw).

Fibre Length: Fibre length is the number of bounding sites that is available on an individual fibre to form an interwoven network of fibres. It is measured from one end to another.

Fibre Diameter: This is the diameter of fibre measured from one side to the other end. It is measured across the fibre length (Jang *et al*, 2002).

Lumen Width: This is the diameter of internal cavity of the fibre. It is the distance between the inner cell wall of the fibre. It is measured as the fibre wall thickness and it is measured in a transverse direction. Fibre lumen width affects the beating of pulp. The larger the lumen width, the easier will be the beating of the pulp because of the penetration of liquid into empty spaces of the fibre.

Derived values for fibre parameters

Important criteria in paper making was also calculated using fiber dimensions: slenderness ratio as fiber length/fiber diameter, flexibility coefficient as (fiber lumen diameter/ fiber diameter) × 100 and Runkel ratio as (2 × fiber cell wall thickness)/lumen diameter (Saikia*et al*.,1997; Ogbonnaya*et al*., 1997).

Chemical compositions

Modified Gravimetric method as procedure adopted byLayokun,S.K. 1981, to determine percentage compositions in: cellulose fibre, lignin and hemicelluloses.

Statistical analysis

Data obtained in the cause of laboratory analysis were subjected to statistical analysis using ANOVA while Duncan Multiple Range Test (DMRT) was used to separate the mean.

RESULTS AND DISCUSSION

Fibre parameters investigated

Fibre length

The average fibre length observed in 2, 4 and 6mm ranged from 0.290-0.300, with highest FL recorded in 6mm while 2and 4mm are the same. The mean ± standard error values for the FL ranges from 0.290 ± 0.0070,0.290 ± 0.0090 and 0.300 ± 0.0080.Meanwhile, at 5% ($p \leq 0.05$) probability level, there was no significant difference among the fibre lengths across the three particle sizes. Therefore, they belong to the classes of short fibre length with achieving bulk, smoothness, and opacity according to Ogunwusi*et al* (2013).

Fibre diameter

The average values observed in fibre diameter from this study ranged from 21.140-25.370µm, while the mean ± standard error values for the FD were 21.140 ± 0.5130,25.370 ± 0.2190 and 24.460 ± 0.9480 respectively. At 5%($p \leq 0.05$) probability level, the result obtained from DMRT as indicated in (table 1) shows that there was significant difference in FD at particle size 2mm, while there were no significant differences between 4 and 6mm. Though, Paper made from FD of this rangewould be expected to exhibit good contact between fibres since fibre diameter and the cell wall govern the flexibility of paper (Akachuku, 2001).

Lumen Width

The values obtained from lumen width of maize cob particle sizes 2, 4 and 6mm in this study ranges from 11.950 –17.190µm, whilethe mean ± standard error values for fibre lumen width across the three particle sizes (Table1) were 11.950 ± 0.8730,17.190 ± 0.3450 and 15.790 ± 1.3120 respectively. The results of DMRT at 5%($p \leq 0.05$) probability level, shows that there was significant difference in LW at particle size 2mm, while there were no significant differences between sizes 4 and 6mm. Though, the values obtained across the three sizes fall within the class of fibre with large lumen width and, hence fibre lumen affect the beating of pulp, the larger the fibre lumen width, the better will be the beating and the penetration of liquid to the empty spaces of the fibre (Young, 1981) and (Bektas*et al*., 1999).

Cell wall thickness

Values obtained for fibre cell wall thickness in this study ranged from 4.090- 4.600, whilethe mean ± standard error values for 2, 4 and 6mm were: 4.600 ± 0.2180,4.090 ± 0.0870 and 4.33± 0.2010 respectively (Table1).The values were very low and considered thin thus, indicates its suitability in paper making.Paper manufactured from thick walled fibres will be dense and possess coarse surface whereas paper made from thin walled fibre will be dense and well formed (Akachuku, 2001). Meanwhile, at 5% ($p \leq 0.05$) probability level, there were no significant differences in the cell wall thickness across the three particle sizes examined (Table1).

Results of chemical composition

Lignin content (%)

The percentage lignin content observed in 2, 4 and 6mm ranged from 10.670-12.670, with the least LC recorded in 2mm while 4and 6mm are almost the same. The mean ± standard error values for the LC across the three sizes were: 10.670 ± 1.7640,12.670 ± 1.3330 and 11.330 ± 0.6670 respectively.Meanwhile, at 5% ($p \leq 0.05$) probability level, there was no significant difference among the LC across the three particle sizes. Though, low LC obtained across the three particle sizes could be an advantage in the sence that lower amount of lignin content indicated lower chemical and energy consumption in the cause of pulping and bleaching of the fibre. (Table 2).

Hemicellulose (%)

The percentage hemicellulose content observed in 2, 4 and 6mm ranged from 26.670-29.330 with the highest HC recorded in 6mm while the same values were recorded in 2and 4mm. The mean ± standard error values for the LC across the three sizes were: 26.670 ± 2.6670,26.670 ± 3.5280 and 29.330 ± 2.6670 respectively. Meanwhile, at 5% ($p \leq 0.05$) probability level, there was no significant difference among the HC across the three particle sizes. (Table 2)

Cellulose content (%)

The percentage cellulose content observed in 2, 4 and 6mm ranged from 34.67- 38.00, with the highest CC recorded in 2mm while 36.00and 34.670 were recorded in 4and 6mm respectively.Paper strength depends on the cellulose content of raw materials Khalil *et al.,* (2006).

The mean ± standard error values for the HC across the three sizes were: 38.000 ± 1.1550,36.000 ± 2.0000 and 34.670 ± 1.7640 respectively.Meanwhile, at 5% ($p \leq 0.05$) probability level, there was no significant difference among the HC across the three particle sizes. (Table 2)

Derived values result for fibre parameters

Felting rate

The mean value for felting rate of maize cob particle sizes ranged from 0.014 to 0.012

The highest felting rate was obtained in 2mm (0.014) while the same value (0.012) were obtained in sizes 4mm and 6mm as shown in the Table 3. The result indicated that there were significant differences at 5% ($p \leq 0.05$) level between the felting rate in 2mm and 4mm with mean ± standard error values of 0.014±0.0006 and 0.012±0 .00032 respectively, while particle size 6mm does not differ significantly at 5% ($p \leq 0.05$) level from size 2mm and 4mm with mean ± standard error value of 0.012±0.00032.

Runkel ratio

The mean Runkel ratio for the three particle sizes ranged from 0.477 - 0.782. The highest (RR) was obtained in 2mm (0.782) while the least (0.447) was recorded in 4mm. All the values obtained were moderately low less than one (< 1). There was significant difference at 5% ($p \leq 0.05$) level in the RR of particle size 2mm and 4mm with mean ± standard error values of 0.782±0.08660, 0.477±0.01930, while particle size 6mm does not differ significantly at 5% ($p \leq 0.05$) level from particle size 2mm and 4mm with mean ± standard error value of0.560±0.07074 (Table 3).This corroborates Runkel, (1952) which says where "**RK** is < 1, the fibre is very good and highly pulpable."

Flexibility Ratio

Flexibility rate of thefibre parameters ranged from 16.127-21.790.The highest Flexibility value (21.790) was observed in 2mm while the lowest was obtained in 4mm as shown in Table 3. There was significant difference at 5% ($p \leq 0.05$) level between the flexibility rate of 2mm and 4mm with mean ± standard error values of 21.790±1.42521 and 16.127± 0.43175 respectively, while particle size 6mm does not differ significantly at 5% ($p \leq 0.05$) level from 2mm and 4mm with mean ± standard error value of 17.827±1.46389.

Table 1: Fibreparameters of maize cobat particle sizes of 2, 4 and 6mm

Parameters	2mm	4mm	6mm
Fibre length (mm)	0.290±0.0070[a]	0.290±0.0090[a]	0.300±0.0080[a]
Fibre diameter (μm)	21.140±0.5130[a]	25.370±0.2190[b]	24.460±0.9480[b]
Lumen width (μm)	11.950±0.8730[a]	17.190±0.3450[b]	15.790±1.3120[b]
CWallthickne (μm)	4.600±0.2180[a]	4.090±0.0870[a]	4.330±0.2010[a]

Mean values along the same row with different superscripts are significantly different at 5% ($p<0.05$) level.

Table 2: Mean chemical parameters of maize cob at particle sizes of 2, 4 and 6mm

Parameters	2mm	4mm	6mm
Lignin (%)	10.670±1.7640[a]	12.670±1.3330[a]	11.330±0.6670[a]
Hemicellulose (%)	26.670±2.6670[a]	26.670±3.5280[a]	29.330±2.6670[a]
Cellulose (%)	38.000±1.1550[a]	36.000±2.0000[a]	34.670±1.7640[a]

Mean values along the same row with different superscripts are significantly different at 5% ($p<0.05$) level.

Table 3: Derived values for fiber parameters of maize cob of particle sizes of 2, 4 and 6mm

Parameters	2mm	4mm	6mm
Felting/slender Ratio	0.014±0.0006[b]	0.012±0 .00032[a]	0.012±0.00032[ab]
Runkel Ratio	0.782±0.08660[b]	0.477±0.01930[a]	0.560±0.07074[ab]
Flexibility coefficient	21.790±1.42521[b]	16.127±0.43175[a]	17.827±1.46389[ab]

Mean values along the same row with different superscripts are significantly different at 5% ($p<0.05$) level.

CONCLUSION

Pulp with desirable fibre characteristics was produced from maize cob through chemical pulping method. Pulp material obtained at 2, 4 and 6mm particle sizes proved better for pulp and paper making when non-wood fibre was considered. Fibre and chemical parameters obtained in this study compared favourably with other wood and non- wood raw materials which are known to be the prime sources of fibre used for paper making. Maize cob therefore is a potential alternative in the pulp and paper based industry.

REFERENCES

Akachuku, A.E and Folorunso (2001); Study of Reaction among some wood features in Hardwood species.*Journal of tropical forest resources* Vol. 5: page 72-78

Bektas I, Tutus andEroglu H. (1999).A study of the suitability of Calabrian Pine (*Pinusburtia,* Jen) for pulp and paper manufacture.*Turk. J. Agri.For.* **23** (3):589-597.

Evers, A.D. and Kent, N.L. 1994. Kents technology of cereals: an international for students of food science and agriculture. *Woodhead pub.Series Food Sci., Techol.Nutr.*

FAO 1998.Food and Agricultural Organization.Prospects jute, Kenaf and allied fibre in African country *FAO Working paper* 1 FAO, Rome, Italy.

Jang, H.F., Weign, G., Set, R. and Wu, C.B. 2002. The effect of fibril angle on the travers collapse of paper making fibre. Paper ijapuu 84 (2):112-1115.

Janson, C., 2012. Breeding for cob traits in maize. In: lowa State Univ. Grad. Thes.Dissert., Paper 12982.

Han, J.S., Mianowski, T., Lin Y.-y., 1999. Validity of plant fiber length measurement—a review of fiber length measurement based on kenaf as a model. In: Sellers, T., Reichert, N.A. (Eds.), Kenaf Properties, Processing and Products. Mississippi State University, pp. 149–167.

Layokun, S.K. 1981. Kinetics of acid hydrolysis of cellulose from sawdust.Pro. 11th Annual Conf. Nigeria Soc. Chem. Engin.,pp.63-8.

Lenz, L.W. 1994. Comparative histology of the female inflorescence of zea mays L..Missuri Bot. Garden 35(4):353-376.

Ogbonnaya, C.I., Roy-Macauley, H., Nwalozie, M.C., Annerose, D.J.M., 1997. Physical and histochemical properties of kenaf (*Hibiscus cannabinus*L.) grown under water deficit on a sandy soil. Ind. Crops Prod. 7, 9–18.

Ogunwusi, A.A. and Onwualu,A.P and Ogunsanwo, O.Y (2013): Raw Materials Research and Development Council, Abuja, Department of Forest Resources Management, University of Ibadan Comparative Analysis of Wood Properties of *Afzelia africana* and *Anogeissus leiocarpus* Growing in Nigeria.

Saikia, S.N., Goswami, T., Ali, F., 1997.Evaluation of pulp and paper making characteristics of certain fast growing plants.Wood Sci. Technol. 31, 467–475.

Sridach, W. (2010). Pulping and paper properties of Palmyra palm fruit fibres. Songklanakarin Journal of Science and Technology, 32(2),pp. 201-205

Runkle, R.O.H. 1952. Pulp from Tropical Woods.Bundesanstalt fur Forst und Holzwirtschaft, ReinbekBez. Hamburg: 20 – 25.

Stenus, P. 2000. '1'. P Forest Products Chemistry.Papermaking Science and Technology 3. Finland: Fapetoy. P.29.

Young JH. 1981. Fiber preparation and approach flow in pulp and paper. In: Casey JP (eds). *Chemistry and chemical technology*, Interscience publishers, New York

Ethnobotanical Study of Blood-Cleansing and Blood-Boosting Plants in Kajola Local Government Area of Oyo State, Nigeria

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ABSTRACT

An ethnobotanical study of plants used for blood-cleansing and blood-boosting in Kajola Local Government area of Oyo State, Nigeria was conducted through structured questionnaires administered to 20 respondents in three (3) towns which were purposively selected based on the availability of target audience in the areas. Herbalists, Herb sellers and aged farmers who have deep knowledge on the use of plants around them were interviewed. Thirty one plants species belonging to 20 families were identified with efficacy in cleansing and boosting blood. Euphorbiaceae family has the highest number of species (4). The recipes, methods of preparation and administration were also documented. The plants are mostly found in the forest, 82% of the plants are common while 18% accounted for the rare species in the study area.

Key words: Ethnobotanical, blood-cleansing, blood-boosting, medicinal plants

INTRODUCTION

From the dawn of human history, man sought cures from this earth in the form of plants, animals, rock, fire, smoke and even sun and moon. Herbal remedies have been used for the cure of ailment for as long as human civilization (Oluwalana and Oluwalana, 2012). The use of herbal medicines and phytonutrients or nutraceuticals has continued to expand rapidly across the world with many people now resorting to these products for treatment of various health challenges in different national healthcare settings (WHO, 2004). The use of herbal medicinal products and supplements has increased tremendously over the past three decades with not less than 80% of people worldwide relying on them for some part of primary healthcare.(Ekor, 2013).In many developed countries the use of herbal remedies has also been widely embraced with complementary and alternative medicines (CAMs) now becoming mainstream in the UK and the rest of Europe, as well as in North America and Australia (Committee on the Use of Complementary, and Alternative Medicine by the American Public, Board on Health Promotion, and Disease Prevention, Institute of Medicine, 2005; Braun *et al*., 2010; Anquez-Traxler, 2011). In these developed countries, the most important among many other reasons for seeking herbal therapy is the belief that it will promote healthier living. Herbal medicines are, often viewed as a balanced and moderate approach to healing and individuals who use them as home remedies and over-the-counter drugs spend huge amount of money (in excess of billions of dollars) on herbal products. This explains in part the reason sales of herbal medicines are booming and represents a substantial proportion of the global drug market (Bandaranayake, 2006).

For centuries, herbs have been used to naturally cleanse the body, this is especially so in the case of blood (Jacks, 2015). Blood is a body fluid in humans and other animals that delivers necessary substances such as nutrients and oxygen to the cells and transports metabolic waste products away from those same cells. The bacteria spread in the environment, gases, polluted water, insomnia, junk foods, etc has tightened its vice grips over the purity of our blood. (Ashish, 2012). The need to cleanse blood of impurities is on the high rise because of the high rate of exposure to pollution, unhealthy activities and thereby leading to various forms of diseases. Cleansing the blood is probably one of the most important weapons in the alternative health arsenal for achieving optimum wellness and defeating cancer (Barron, 2007). Lack of physical activity, poor consumption of healthy food, and over consumption of animal based products can lead to a build-up of toxins in the blood and body. Cleansing the blood is a good way to improve immunity, prevent heart diseases, improve overall health and fight cancer. (Trina, 2014).

Herbal blood cleansers are used to remove toxic residues from the blood so that the blood and body resist cancer and tumors. Ninety percent of all ailments affecting the body come from the accumulation of waste in the body, waste from different types of foods. Many of these ailments have the same treatment which is basically cleansing the blood, cleansing the stomach, cleansing the intestines and the bowels and cleansing the body cavity of accumulated mucus. Once the waste is cleaned, there will be positive results, just by changing diet alone (Lewis 2010). Blood cleanser is the element which helps in cleansing or detoxifying the impurities present in the blood. Blood cleansers may include the blood cleansing diet, food or juices, any other substance which helps in purifying or cleansing of blood.

In many developing countries, most especially Nigeria, medicinal plants for blood- cleansing have not been well studied, tested, or documented. Most of the information is still in the hands of traditional healers and knowledge of healers is either lost or passed to next generation by the word of mouth. The preliminary study focused on the identification and proper documentation of medicinal plants and recipes used for cleansing and boosting blood, and it is hoped that further research work would be carried out to ascertain the bioactive compounds responsible for their potency.

METHODOLOGY

Study Area

The study was carried out in Kajola Local Government Area of Oyo State, Nigeria. Okeho is the headquarters of the Local Government Area Other major towns in the local government are, Ilero, Ayetoro-Oke, Iwere-Oke, Isemi-Ile and Ilua. The Local Government has an area of 609km^2 and a population of 200,997 (NPC, 2006)

Data collection

The required information on medicinal plants found to be useful for blood-cleansing and blood-boosting were collected from a direct field survey based on the questionnaire administration and interview guide. This work was directed at herb sellers, traditional healers and farmers who have deep knowledge about the use of plants around them or have inherited the knowledge from their forefathers. Generally the respondents were randomly selected in the three selected towns: Okeho, Ayetoro-Oke and Ilero of the Local Government Area. A total of 60 respondents were interviewed.

RESULTS AND DISCUSSION

Demographic features of the respondents in the study area

Table 1 showed the demographic features of the respondents in the study area. Sixty-eight percent of the respondents were males while 38% were females. All the female respondents are herb sellers but the males consisted of farmers who have deep knowledge about the use of plants around them and Herbalists. The table also showed the age distribution, most of the respondents fall within the age bracket of 40-70years. All the respondents were married. Of the 60 respondents, 50 had no formal education. This showed that information about blood-cleansing and blood-boosting is held orally by most respondents. This is a clear danger to the continuity of the knowledge documentation without storing in black and white.

Recipes and method of administration

Table 2 showed Plants, recipes, methods of preparation and administration of the Blood-cleansing and Blood-boosting plants in the study area. The methods of preparation are by decoction, infusion, grinding, squeezing of leaves and partial pyrolysis and grinding. Decoction accounted for a frequency of 16, while squeezing of leaves to extract the juice was 3.

Method of preparation and their prices

Grinding, infusion and partial pyrolysis accounted for one (1) each, (Table 3). The selling price of decoction varied from ₦ 100-2000, with ₦ 500 having the highest frequency, the selling price of infusion was ₦ 500. The selling price of squeezed leaves ranged from ₦ 100-300. In all, selling price from ₦ 500-2000 accounted for 73% of the prices. The duration of treatment ranged from 3-30days (Table 2).

Plants for blood-cleansing and blood-boosting encountered in the study area

Table 4 summarizes the identified plants for blood cleansing and blood-boosting purposes in the study area. Thirty-one plants were encountered which include nineteen (17) trees, ten (9) shrubs and five (5) herbs respectively. The distribution by habitat shows that most of the plants species are obtained from the forest while others could be obtained from home garden and farm. The part of the plant species used most is the bark. Other parts such as the leaf, stem, twig, seed and fruit .Table 5 shows the family distribution of plants used for blood-cleansing and blood-boosting in the study area.

Table 1: Demographic features of the respondents

Variables	**Frequency**	**Percentage frequency**	**Mode**
Gender			
Male	37	62	Male
Female	23	38	
Age classification (years)			
31-40	3	5	
41-50	18	30	
51-60	21	35	51-60 years
61-70	15	25	
71-80	3	5	
Marital status			
Married	55	92	Married
Widow	5	8	
Level of Education			
	50	83.33	No formal Education
No formal Education	6	10	
Primary School	2	3.33	
Junior Secondary School	1	1.67	
Senior Secondary School	1	1.67	
Nigeria Certificate in Education			

Source: Field survey, 2013

Table 2: Plants, Recipes, Methods of preparation and administration of the Blood-cleansing and Blood-boosting plants in the study area

SN	Plant Name (Recipes)	Local Name	Parts Used	Method of Preparation	Dosage/ Purpose	Duration of usage	Price/preparation (₦)
1	*Eclipta prostrata* *Xylopia aethiopica*	Aape Eeru	Fresh Bark Dried Fruit	The plants materials are boiled together for about an hour and decanted.	Drink one cup daily for blood boosting.	14days	500
2	*Eclipta prostrata* *Sorghum bicolor*	Aape Poroporo	Fresh bark Fresh leaves	The plants materials are boiled together in to decoction for about an hour.	Drink one cup daily for blood boosting.	14days	500
3	*Annona senegalensis* *Khaya grandifoliola* *Eclipta prostrata* *Adenopus breviflorus*	Abo Agano Aape Tagiiri	Fresh Root Fresh Bark Fresh Bark Fresh Fruit	The plants materials are infused for 3-4days.	Drink one cup daily for blood cleansing.	7days	1500
4	*Bridelia micrantha* *Vitellaria paradoxa* *Khaya grandifoliola*	Asaa Emigbegi Agano	Fresh Bark Fresh Bark Fresh Bark	The plants materials are boiled together in to decoction for about an hour	Drink a cup daily on empty stomach for blood cleansing and boosting remedy.	10days	1500
5	*Cynometra megalophylla,* *Khaya grandifoliola* *Lannea welwitschii,* *Bridelia ferruginea.*	Ata Agano Opon Ira	Fresh Bark Fresh Bark Fresh Bark Fresh Bark	Decoction of bark of the plants	Drink one cup daily for blood cleansing.	7days	1500
6	*Theobroma cacao*	Koko	Fresh leaves, bark	Cook the leaves and bark for about 20 minutes.	Drink one to two cups daily for blood boosting.	8days	2000
7	*Azadirachta indica*	Dogoyaro	Fresh Leaves, Bark, twig.	Boil some leaves for 30 minutes, allow to cool	Drink small cup twice daily for blood cleansing. **OR** consume 2-3leaves for blood cleansing.	3days	200
8	*Vitellaria paradoxa* *Eclipta prostrata* *Daniella oliverii*	Emigbegi Aape Iya	Fresh Bark Fresh Bark Fresh Bark	Boil the bark of the plants for an hour. Allow to cool and decant.	Drink a cup daily for blood cleansing and boosting.	30days	500
9	*Olax subscorpioidea,* *Securidaca longipedunculata* *Daniella oliverii*	Ifon Ipeta Iya	Fresh Root Fresh Root Fresh Bark	The root and leaves of the plants are boiled together for about an hour, then decant.	Drink a small cup daily for blood cleansing and boosting.	7days	600
10	*Daniella oliverii*	Iya	Fresh Bark	Decoction of the bark.	Drink two cups daily for blood boosting	7days	500
11	*Stropthantus gratus* *Perquatina nigrescens* *Bridelia micrantha* *Vitellaria paradoxa* *Khaya grandifoliola*	Isa Ogbo Asaa Emigbegi Agano	Fresh Root Fresh Root Fresh Bark Fresh Bark Fresh Bark	The plants materials are cooked thoroughly	Small cup of the mixture is taken on a daily basis for blood cleansing and boosting.	14days	1200
12	*Antiaris Africana* *Daniella oliverii*	Ooro Iya	Fresh Bark Fresh Bark	The barks of the plants are cooked thoroughly.	Small cup of the mixture is drunk two	7days	500

					times in a day for blood boosting.		
13	*Khaya grandifoliola* *Adenopus breviflorus* *Allium cepa*	Agano Tagiiri Alubosa elewe	DriedBark Dried Fruit Dried Leaves	The bark, fruit of and leaves of is ground together until a uniform mixture is obtained after which local black soap is used to mould the mixture.	One teaspoonful is dissolved in water completely. The solution is then taken on an empty stomach at three days interval for blood cleansing.	30days	1000
14	*Viscum album*	Afomo	Dried Leaves, twig	The leaves and young twigs are cooked for an hour	The extract is taken as tea for blood cleansing. **Caution:** This herbal mixture is strictly recommended for adult, two to three spoonfuls are recommended for the adult per week.	14days	1000
15	*Vernonia amygadalina*	Ewuro	Fresh Leaves, young twigs	Squeeze fresh leaves	The juice is drunk on an empty stomach for blood cleansing.	5days	200
16	*Phyllantus amarus*	Eyin -olobe	Fresh Leaves	The leaves are cooked as tea	The extract is taken in small quantity as blood cleanser. The leaves could also be grounded to powder and used as desired.	10days	500
17	*Telfaria occidentalis*	Ugwu	Fresh Leaves	The leaves are squeezed.	Milk is added to the juice and taken for blood boosting	7days	300
18	*Phyllantus reticulatus* *Xylopia aethiopica* *Thebroma cacao*	Iranje Eeru Koko	Fresh Leaves Dried Fruit Fresh Bark	The plant materials are boiled for about an hour.	Drink small cup daily for blood cleansing.	6days	1300
19	*Jatropha curcas*	Lapalapa-funfun	Fresh Leaves, Bark	Decoction of the bark and leaves.	Small cup of the extract is taken on an empty stomach for blood cleansing.	7days	500
20	*Jatropha gossypifolia* *Aframomum melegueta*	Lapalapa-pupa Ataare	Fresh Leaves Dried Seed	Fruit and seed of the plants are burnt and ground to powder	The powder is taken with hot pap as desired for blood cleansing.	10days	400
21	*Jatropha tanjorensis*	Iyanapaja	Fresh Leaves	The leaves are squeezed	Evaporated milk is added to the juice and taken for blood boosting.	5days	250
22	*Ocimum gratisssimum*	Efirin	Fresh Leaves	The leaves are boiled	The extract is taken on empty stomach. Also, the fresh leaves (2-3leaves) can be chewed raw for blood cleansing	3days	100

Source : Field survey, 2013

Table 3: The selling price frequency and various form of preparation of the blood-cleansing and blood-boosting plants in the study Area

Price (₦)	Decoction	Infusion	Grinding	Squeezing	Partial pyrolysis	Frequency
100	1					1
200	1			1		2
250				1		1
300				1		1
400					1	1
500	7					7
600	1					1
1000	1		1			2
1200	1					1
1300	1					1
1500	2	1				3
2000	1					1
Total	**16**	**1**	**1**	**3**	**1**	**22**

Source: Field survey,2013

Table 4: Plants species used for Blood-cleansing and Blood-boosting in the study area

S/N	Name of Plants	Botanical Name	Family	Form	Habitat
1	Aape/ Apepe	*Eclipta prostrata* Linn.	Asteraceae	Tree	Forest
2	Abo	*Annona senegalensis.*Pers.	Annonaceae	Tree	Forest
3	Afomo	*Viscum album* Linn	Viscaceae	Shrub	Forest
4	Agano/ Mahogany	*Khaya* grandifoliola (Welw) CDC	Meliaceae	Tree	Forest
5	Alubosa elewe	*Allium cepa* Linn.	Liliaceae	Herb	Homegarden
6	Asaa	*Bridelia micrantha*. Hochst.	Euphorbiaceae	Tree	Forest
7	Ata	*Cynometra megalophylla*. Harms.	Fabaceae	Tree	Forest
8	Ataare	*Aframomum melegueta* K.Schum.	Zingiberaceae	Herb	Forest
9	Koko (Cocoa)	*Theobroma cacao* Linn.	Malvaceae	Tree	Cocoa farm
10	Dogoyaro /Gbogbolese	*Azadirachta indica.* Juss.	Meliaceae	Tree	Forest
11	Efirin	*Ocimum gratisssimum* Linn.	Lamiaceae	Herb	Home garden
12	Emigbegi	*Vitellaria paradoxa* C.F.Gaertn.	Sapotaceae	Tree	Forest /Farmland
13	Erun	*Xylopia aethiopica* (Dunal)A.rich	Annonaceae	Tree	Forest
14	Ewuro	*Vernonia amygdalina.* Del.	Asteraceae	Shrub	Home garden
15	Eyinolobe	*Phyllantus amarus* Schumach&Thonn.	Phyllanthaceae	Shrub	Forest
16	Ifon	*Olax subscorpioidea* .Oliv.	Olacaceae	Tree	Forest
17	Ipeta	*Securidaca longipedunculata.* Fres.	Polygalaceae	Tree	Forest
18	Ira	*Bridelia ferruginea.* Benth	Phyllanthaceae	Tree	Forest
19	Iranje	*Phyllantus reticulatus Poir*	Phyllanthaceae	Shrub	Forest
20	Isa	*Strophantus gratus.* Oliv	Apocynaceae	Tree	Forest
21	Iya	*Daniella oliverii* (Rolfe)hutch & Secandens	Fabaceae	Tree	Forest
22	Iyanapaja	*Jatropha tanjorensis* Linn.	Euphorbiaceae	Herb	Home garden
23	Korikooba	*Cymbopogon citratus*DC.	Poaceae	Herb	Home garden
24	Lapalapa funfun	*Jatropha curcas* Linn.	Euphorbiaceae	Shrub	Home garden
25	Lapalapa pupa	*Jatropha gossypifolia* Linn.	Euphorbiaceae	Shrub	Home garden
26	Ogbo	*Parquetina nigrescens.* Afzel.	Apocynaceae	Shrub	Forest
27	Ooro	*Antiaris africana* Engl.	Moraceae	Tree	Forest
28	Opon	*Lannea welwitschii.* Hiern	Anacardiaceae	Tree	Forest
29	Poroporo	*Sorghum bicolor* Linn.	Poaceae	Shrub	Farmland

30	Tagiiri	*Adenopus nodiflora.Linn.*	Verbenaceae	Tree	Forest
31	Ugwu	*Telfaria occidentalis.*Hook f	Cucurbitaceae	Shrub	Home garden

Source: Field survey, 2013

Table 5: Distribution within plant families of medicinal plant species used in Blood-Cleansing and Blood-Boosting in the study area.

SN	Family	Species	SN	Family	Species
1	Anacardiaceae	1	11	Meliaceae	2
2	Annonaceae	2	12	Moraceae	1
3	Apocynaceae	2	13	Olacaceae	1
4	Asteraceae	2	14	Phyllanthaceae	3
5	Cucurbitaceae	1	15	Poaceae	2
6	Euphorbiaceae	4	16	Polygalaceae	1
7	Fabaceae	2	17	Sapotaceae	1
8	Lamiaceae	1	18	Verbenaceae	1
9	Liliaceae	1	19	Viscaceae	1
10	Malvaceae	1	20	Zingiberaceae	1

Source : Field survey.

From the study, thirty-one (31) plants which consist of seventeen trees, nine shrubs and five herbs respectively are belonging to 20 different families with Euphorbiaceae having the highest frequency. 82% of the plants are relatively available while 18% are rare. Some of the species that were reported to be rare in the study area include ; *Khaya grandifoliola, Phyllantus amarus, Antiaris africana* etc. The result shows that most of the respondents dealing with blood-cleansing and blood-boosting plants have no formal education This simply means that majority of the people that have in-depth knowledge about the usefulness of the plants are not educated. This knowledge might have been acquired from their parents or from the aged ones within their locality this has made it impossible for them to annex the resources on a sustainable basis, they simply believed that nature has a way of replenishing itself and there is no serious need for conservation. This mentality of theirs could be attributed to the fact that they have no formal education... The method of preparation is simple and can be easily prepared by anyone in need. According to the study, anyone that make use of the plant resources will be freed from various ailment that results from internal and external toxins which is a major challenge confronting the social and economic stability of the nation.

Some of the listed plants in this work have also been reported by respondents to be useful in the treatment of other ailments such as:

Malaria and Haemorrhoids : *Daniella oliverii, Annona senegalensis* and *Eclipta prostrata, Khaya grandofoliola, Azadirachta indica, Vernonia amygdalina.*

Liver cleansing: *Phyllantus amarus.*

Heart problem: *Antiaris africana* .

CONCLUSION

This work shows that plants are used for blood-cleansing and blood-boosting purposes in the study area and the prices are relatively cheap in comparison with allopathic care. It is suggested that pharmacological studies should be done on the plants identified. Also, trees, shrubs and herbs are exploited because; most of the plants are sourced from the forest. Plants not replaced in the forest face the possibility of extinction. Therefore, planting in home gardens should be encouraged.

REFERENCES

Anquez-Traxler C. (2011). The legal and regulatory framework of herbal medicinal products in the European Union: a focus on the traditional herbal medicines category. *Drug Inf. J.* 45 15–23 10.1177/009286151104500102

Ashish Kumar,(2012).Impurity in Blood: Its Symptoms, Causes and Preventive measures. www.indiastudychannel.com/resources/150766-Impurity-in-blood-Its- symptoms- causes.aspx Assessed 11/30/2012

Blumenthal M., Brusse W. R., Goldberg A., Gruenwald J., Hall T., Riggins C. W., et al. (1998). *The Complete German Commission E Monographs. Therapeutic Guide to Herbal Medicines*. Austin, TX:The American Botanical Council.

Braun L. A., Tiralongo E., Wilkinson J. M., Spitzer O., Bailey M., Poole S., et al. (2010). Perceptions, use and attitudes of pharmacy customers on complementary medicines and pharmacy practice. *BMC Complement. Altern. Med.* 10:38 10.1186/1472-6882-10-38.

Committee on the Use of Complementary,and Alternative Medicine by the American Public Board on Health Promotion Disease Prevention Institute of Medicine. (2005). *Complementary and Alternative Medicine in the United States*. Washington, DC:The National Academies Press.

Ekor, M., (2013). The Growing Use of Herbal Medicine: Issues relating to Adverse Reactions and Challenges in Monitoring Safety. Front Pharmacol 2013; 4:177. Published online 2014 Jan.10.doi:10.3389/fphar,2013.00177.

Jacks Brenna, (2015): Top 5 Cleansing Herbs.https//www.alive.com/health/top-5-cleeansing –herbs/. Assessed 12th August, 2015.

Jon Barron, (2007): Cleansing your Blood. www.a lternatiive-health-group.org/ blood cleansing. Assessed 11/20/2012

Lewis Kiwanuka R.G., (2010): Causes of Blood Impurities. http/www.blackherbal.com/ cleansing the blood of impurities Assessed 11/30/2012

Samuel Oluwalana, Funmi Oluwalana(2012): Remedies for Common Ailment. Ministry of Eternal Affairs Publisher, 5 Wagtail Way, Orpington, BR5 3NB UK.

Trina Remedois 2014: Herbal Remedies: 15 Indian Herbs to Cleanse the Blood.www.Indian times.com/health/ healthy living/ herbal remedies-15 Indian herbs to cleanse the blood-237395.html. Assessed 19th September, 2015.

World Health OrganizationWHO. (2004). *WHO Guidelines on Safety Monitoring of Herbal Medicines in Pharmacovigilance Systems*. Geneva, Switzerland: World Health Organization.

Evaluation of the nutritional and medicinal properties of *Piper guineense* (West African Black Pepper) Leaves

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ABSTRACT

Freshly harvested leaves of Piper guineense (West African Black Pepper) were collected and evaluated for its nutritional and medicinal properties. Proximate analysis, vitamin analysis, mineral analysis and phytochemical analysis of P. guineense leaves were carried out according to the standard methods. It was observed that P. guineese has high content of protein, fiber, calcium, magnesium, iron, cardiac glycoside, vitamin A, and C. The results of this study revealed that the presence of vitamins and minerals in the fresh leaves of P. guineense make it suitable as a good spice for Nigerian food. This will promote the health of teeth and gums, lungs and bronchia, and joints, aids the purification of blood. The phytochemical results justified the use of the leaves of P. guineense for treating malaria, heart problems and some other health problems. Likewise, its uses have spread across for the treatment of malaria, heart problem, fertility and many more. However, caution has to be taken in the usage of the plant to avoid any negative effect that may come as a result of misuse.

Key Words: *Piper guineense*, spices, nutrient values, vitamins, medicinal value

INTRODUCTION

Piper guineense is a spice plant from the family Piperaceae and from genus piper. It is a West African spice plant known as Ashanti pepper in Ghana, as Uziza in Igbo and Iyere in Yoruba. It is also known as Benin pepper, Guinea pepper and false cubeb (Balogun *et al.,* 2016). *P. guineense* are vines that grow up to 20m tall climbing up bole of trees by means of adventitious roots. It is a perennial plant that is characterized by heart-shaped leaves and oval, petiole, alternate, 12cm long. The leaves which have a peppery taste, are pale greenish colour when fresh and darker green when frozen or dried. The inflorescence is a pedicel flower spike between 3 and 6cm long and the peduncle 5mm long. Flowers are greenish yellow and arranged in a spiral along the spine (Agoha, 1974). The fruits of *P. guineense* occur in clusters, small, reddish or reddish brown when ripe and black when dry (Okwute, 1992). The fruit is a drupe mesocarp or fleshy, oval, 5mm in diameter.

P. guineense have nutritional and non nutritional factors which are responsible for its aroma, flavour and preservative properties. Dada *et al.,* (2013) confirmed that *P. guineensis* (Black peper) is a local spice that comprises of dillapiol, 5-8% of piperine, elemicine, 10% of myristicine and safrole and these chemicals exhibit bactericidal and antimicrobial effects on certain microorganisms. These effects have been associated with the presence of phytonutrients such as flavonoids, alkaloids, glycosides, essential oils, tannins, saponins, peptides and phenols in this spectacular plant. Uhegbu *et al.,* (2015) cited Marcel *et al.,* (2010) to confirm that spices are aromatic vegetable substances that are used in small quantities for seasoning of foods and also used as preservatives or flavouring and thus enhancing the taste of food, beverage and drugs Spices contain essential oils which are complex mixtures of organic compounds called phytochemicals. Spices generally are parts of various plants cultivated for their aromatic pungent or otherwise desirable substances. They consist of rhizomes, bulbs, flower bud, fruit, seed, and leaves. They usually are categorized into tiny wild fruits, nuts, herbs, and leafy vegetables (Balogun *et al.,* 2016). Agoha (2002) reported that the leaves and seeds of the plant are used to flavour soup, stew and food generally. Spices not only just excite your taste buds but are composed of an impressive list of phyto-nutrients, essential oils, antioxidants, minerals and vitamins that are essential for overall wellness. Spices have been integral part of our food since centuries, and today, even become more relevant for us. Spices are also known to have natural anti-helminthes (control worm infestation) function in traditional medicines. Spice's essential oils are being used in the aromatherapy as well as de-odorants in the perfume industry. Spices contain an impressive list of plant-derived chemical compounds that are known to have disease preventing and health promoting properties. They have been in use since ancient times for their anti-inflammatory, carminative, anti-flatulent properties. The components in the spices have been found to have anti-clotting action (prevent clogging of platelets in the blood vessels) and thus help easing blood flow, preventing stroke and coronary artery disease. Spices contain a good amount of minerals like potassium, manganese, iron, and magnesium. Potassium is an important component of cell and body fluids that helps in controlling heart rate and blood pressure. Manganese is used by the body as a co-factor for the antioxidant enzyme, superoxide dismutase.

Piper guineense apart from being used as spices and condiments, have several other wide applications in the local treatment and management of many diseases. It has significant antioxidant activity owing to its free radical scavenging potential (Etim *et al*., 2013). Sumathykutty *et al.,* (1999) agreed that *P. guineense* leaves are aseptic in nature, with the ability to relieve flatulence.

They are also useful for treating intestinal diseases, cough, bronchitis and rheumatism. According to the research carried out by Nwachukwu *et al.,* (2010), on the uses of some medicinal plants, they found out that *P. guineense* (Black pepper) is suitable for treating Infertility in women and Low sperm count in men. Bep (1999) reported that the seeds of *Piper guineense* are used to relieve discomfort in the stomach caused by excess gas. The leaves of the plant are used to treat respiratory infections, rheumatism and syphilis. The leaves are also used for female infertility while the fruits are used as an aphrodisiac (Mbongue, 2005). Generally, *Piper guineense* seeds are used in the preparation of drugs for treatment of cough, intestinal diseases, viral diseases, cold and rheumatism. In the South Eastern parts of Nigeria, the fruits are used to prepare soups for mothers from the first day of delivery to prevent post partum contraction and to aid in the fast return of the uterine muscles to the original shape, and increase the flow of the nursing mothers' breast milk (Uhegbu, *et al.,* 2015). Olawuyi *et al.,* (2013) confirmed that *P. guineense* has insecticidal properties. This is evident in several studies where *Piper guineense* powder, oil and hexane and acetone extracts have been effective in causing mortality and reducing oviposition of various insects when applied to grains and tree seedlings. Etim *et al.,* (2014) investigated the effects of *Piper guineense* and *Azadirachta indica* on some Polycyclic Aromatic Hydrocarbons Levels in Leaves of Germinating *Telfairia occidentalis* (ugu). The result of their findings suggested that *P. guineense* leaves could be used to bioremediate or reduce phenanthrene, chrysene, benzo(b) fluoranthene, dibenzo (a,b) anthracene and indeno (1,2,3-cd) pyrene levels. However, the present study aimed to evaluate the nutritional and anti – nutritional values of *Piper guineense* (African Black Pepper), for the purpose of exploring more uses to which the plant may be put to.

MATERIALS AND METHODS

Collection of sample plant

Freshly harvested leaves of *Piper guineense* (African Black Pepper) shown in Plate 1 were collected from Ibusogboro at Onigambari Forest Reserve, Oyo State, Nigeria. The plant was identified in the herbarium of Forestry Research Institute of Nigeria (FRIN), Ibadan.



Figure 1: Harvested *Piper guineense* Leaves from Busogboro, Onigambari

Proximate Analysis

Moisture content, ash, crude fiber, oil, protein and total carbohydrates were determined according to AOAC (2005). Total carbohydrates were obtained by subtraction of contents moisture, ash, crude fiber, oil, protein from 100.

Vitamins Analysis

Vitamin A, Vitamin B_1, Vitamin B_2, Vitamin B_3, Vitamin C and Vitamin D analyses were determined according to AOAC (2005). The analyses were carried out in the laboratory of Institute for Agriculture Research and Training (IAR&T), Moor Plantation, Ibadan, Oyo State, Nigeria.

Estimation of minerals in plant materials (Estimation by ASS)

Piper guineense leaves were taken in a pre-cleaned and constantly weighed silica crucible and heated in a muffle furnace at 400°C till there was no evolution of smoke. The crucible was cooled at room temperature in a desiccators and carbon-free ash was moistened with concentrated sulphuric acid and heated on a heating mantle till fumes of sulphuric acid ceased to evolve. The crucible with sulphate ash was heated in a muffle furnace at 600°C till the weight of the content was contact (2 – 3h). One gram of sulphate ash obtain above was dissolved in 100 ml. 5 % HCl to obtain the solution ready for determination of mineral element

through Atomic Absorption Spectroscopy (AAS) (AA 800, Perkin-Elmer Germany). Standard solution of each element was prepared and calibration curves were drawn for each element using AAS.

Phyto-chemical Analysis

The percentage compositions of saponins, tannins, alkaloids, oxalate, steroid and cardiac glycoside were determined according to the methods described by A.O.A.C. (2005)

RESULTS AND DISCUSSION

Proximate Composition of Fresh *Piper guineese* (Leaf)

Table 1 showed the result for proximate analysis of the *Piper guineese.* It was revealed that *Piper guineese* is highly nutritious. *Piper guineese* contained 5.57% of protein. This result is in agreement with Negbenebor *et al.,* (1999) as cited by Balogun *et al.,* (2016). Its high protein serves as a supplement for the daily protein requirement of the body and could be responsible for its use in anti-malaria remedy (Isong and Essien, 1996). *P. guineese* contained 7.86% of crude fibre. This high quantity of crude fibre of the plant, suggest easy digestibility of nutrients and it is suitable as supplement in food in addition to anti-malarial activity (Gbadamosi *et al.,* 2011). It also contained 1.18% of crude fat, 2.69% of total ash, 71.08g of moisture content, 28.92% of dry matter and 11.62% of NFE. The result showed that moisture content has the highest percentage of 71.08g in *Piper guineese,* while the least of the nutrient in *Piper guineese* was Total ash with 2.69%. The results are in agreement with Negbenebor *et al.,* (1999), Gbadamosi *et al.,* (2011) and Okonkwo and Ogu (2014).

Table 1: Proximate Analysis of Fresh *Piper guineese* (Leaf)

Nutrient	%
Crude protein	5.57
Crude fat	1.18
Crude fibre	7.86
Total ash	2.69
Moisture content	71.08
NFE	11.6
TOTAL	100

Minerals Composition of Fresh *Piper guineese* (Leaf)

Table 2 showed the mineral composition of *Piper guineese.* It contained 158.92mg/kg of sodium, 681.09mg/kg, and 337.65mg/kg of calcium. *Piper guineese* contained 517.82mg/kg of magnesium, 0.67mg/kg of copper, 0.26mg/kg of manganese, 0.037mg/kg of iron and 0.41mg/kg of zinc. This result showed that *Piper guineese* is highly rich in potassium and magnesium being the highest minerals, while the least minerals are iron, manganese, zinc and copper in that order. The results obtained in this study were higher than as it was reported by Negbenebor *et al.,* (1999), Okonkwo and Ogu (2014) and Ilodibia *et al.,* (2016).

Table 2: Mineral Composition of Fresh *Piper guineese* (Leaf)

Mineral composition	Mg/kg
Sodium	158.92
Potassium	681.09
Calcium	337.65
Magnesium	517.82
Copper	0.67
Manganese	0.26
Iron	0.073
Zinc	0.4

Vitamins Composition of Fresh *Piper guineese* (Leaf)

Table 3 showed different types of vitamins that are contained in *Piper guineese.* The results showed that *Piper guineese contained 49.65um*/100g of vitamin A, 2.67µm/100g of vitamin B_1 and 0.36um/100g of vitamin B_2. It also contained 11.48um/100g of vitamin B_3, 8.64um/100g of vitamin and 133.26um/100g of vitamin D. The result showed that vitamin D is the highest vitamin in *Piper guineese,* followed by vitamin A, while vitamin B_2 is the least among the vitamins available in *Piper guineese.* Since vitamin C (ascorbic acid) promotes the health of teeth and gums, lungs and bronchia, and joints, aids the purification of blood (Ogunlesi *et al*., 2010), its (ascorbic acid) presence in the leafy vegetables more especially in African black pepper leaf with the highest vitamin C content suggests that its consumption and use in herbal medicine can prevent common cold and other diseases like prostate cancer (Igile *et al*., 2013). Uhegbu *et al.,* (2011) reported that *Piper guineese* contained 7.09u/100g of vitamin A,

5120u/100g of vitamin C and 1.64 u/100g of vitamin E. Meanwhile, Bouba *et al.,* (2012) confirmed *Piper guineese* contained 9.3g/100g of vitamin A, 2.7g/100g E and 0.9g/100g of vitamin C.

Table 3: Vitamins of Fresh *Piper guineese* (Leaf)

Vitamins	Ug/100g
Vitamin A	49.65
Vitamin B_1	2.67
Vitamin B_2	0.36
Vitamin B_3	11.48
Vitamin C	8.64
Vitamin D	133.26

Phyto- Chemicals Composition of Fresh *Piper guineense* (Leaf)

Table 4 showed that *piper guineese* contained six anti-nutrient elements. They are tannin, saponin, alkaloid, oxalate, steroid and cardiac glycoside. Gbadamosi *et al.,* (2011) reported that saponins have anti-carcinogenic properties and other health benefits. They may also play a significant role in anti-malaria activity of plants (Adesokan and Akanji, 2010). The presence of alkaloid in high quantity in *P. guineense* confirmed the findings of Ajaiyeoba *et al.,* (2006) that the traditional use of the plants for the treatment of malaria was due to the presence of alkaloids. The medicinal plants that are moderately rich in alkaloids and tannins have potential health promoting effects (Ikewuchi and Ikewuchi, 2008; Jigam *et al.,* 2010). The cardiac glycosides are used for treating heart problems that may result from severe malaria attack (Fatoba *et al.,* 2003).

Table 4: Anti-Nutritive Factors of Fresh *Piper guineese* (Leaf)

Anti-nutrients	Status
Tannin	+
Saponin	++
Alkaloid	+++
Oxalate	+++
Steroid	+
Cardiac glycoside	++

CONCLUSION AND RECOMMENDATION

Piper guineense, a spice plant from the family Piperaceae and from genus piper was studied for its nutritional and medicinal properties. It was found out that *P. guineense* contained appreciable amount of protein, crude fat, crude fibre, total ash, moisture content, dry matter and NFE. It also contained essential vitamins A, B (1, 2, 3), C and D. It contained essential minerals and phytochemical elements in the right quantities. This justified the multi-utilisation of the *P. guineense* within the West Africa. It is known to be primarily used as a spice to give sweet aroma and taste to food. Likewise, its uses have spread across for the treatment of malaria, heart problem, fertility and many more. However, caution has to be taken in the usage of the plant to avoid any negative effect that may come as a result of misuse.

REFERENCES

A.O.A.C. 2005. Official Methods of Analysis of AOAC International. Association of Official Analytical Chemists, Washington, DC, USA.

Adesokan A. A. and Akanji M. A. 2010. Antimalarial Bioactivity of *Enantia chlorantha* stem bark. Medicinal Plants: *Phytochemistry, Pharmacology and Therapeutics 4(1): 441 – 447.*

Agoha A. E. (2002). Uses of *Piper guineense* fruits. *Journal of Food Sci*. 10 (3): 231-238

Agoha,R.C (1974). Medicinal plants of Nigeria, offset Arakkenji, Faculfcider Wiskunde, The Netherlands, pp. 33-41.

Ajaiyeoba E, Falade M, Ogbole O, Okpako L, Akinboye D, 2006. In vivo antimalarial and Cytotoxic properties of *Annona senegalensis* extract. *African Journal of Traditional, Complementary and alternative Medicine 3(1): 137 – 141.*

Balogun, M. E., Besong, E. E., Djobissie, S. F. A., Mbamalu, O. S. and Obimma, J. N. 2016. A Review of *Piper guineense* (African Black Pepper). *International Journal of Pharmacy and Pharmaceutical Research (IJPPR) Vol. 6 (1): 368-384.*

Bep E. O. (1999). Medicinal Plants in Nigeria. *J. of Agric and Food Sci.* 7: 218-225

Bouba, A. A., Njintang, N. Y., Foyet, H. S., Scher, J., Montet, D., and Mbofung, C. M. F. 2012. Proximate Composition, Mineral and Vitamin Content of Some Wild Plants Used as Spices in Cameroon. *Food and Nutrition Sciences*, 2012, 3, 423-432

Dada A. A., Ifesan B. O. T. and Fashakin J. F. (2013), Antimicrobial And Antioxidant Properties Of Selected Local Spices Used In "Kunun" Beverage In Nigeria, *Acta Sci. Pol., Technol. Alignment,* issue 12, vol. 4, p.374.

Etim, O. E., Chinaka, N. C. and Duru, R. U. 2014. Effects of *Piper guineense* and *Azadirachta indica* on some Polycyclic

Aromatic Hydrocarbons Levels in Leaves of Germinating *Telfairia occidentalis* (ugu). *International Journal of Environmental*
Bioremediation & Biodegradation, 2014, Vol. 2, No.
Etim, O.E., Egbuna, C.F., Odo, C.E., Udo, N.M., and Awah, F.M. (2013). In vitro antioxidant and Nitric oxide scavenging Activities of Piper guineense. Global *J. Res. Med. Plants & Indigen. Med. 2(7). 485-494.*
Fatoba PO, Omojasola PF, Awe S, Ahmed FG, 2003. Phytochemical screening of some selected tropical African Mosses. *Nigerian Society for Experimental Biology (NISEB) Journal 3(2): 49 –52*
Gbadamosi I.T., Moody J. O. and Lawal A. M. 2011. Phytochemical screening and proximate analysis of eight ethnobotanicals used as antimalaria remedies in Ibadan, Nigeria. *Journal of Applied Biosciences 44: 2967 – 2971*
Igile, G. O., Iwara, I. A., Mgbeje B. I. A., Uboh, F. E. and Ebong, P. E. (2013). Phytochemical, proximate and nutrient composition of *Vernonia calvaona* Hook (Asterecea): A green-leafy vegetable in Nigeria. *Journal of Food Re-search 2 (6):1 - 11.*
Ikewuchi C. C. and Ikewuchi J. C. 2008. Chemical profile of Pleurotus tuberregium (Fr) Sing's Sclerotia. *The Pacific Journal of Science and Technology 10(1): 28 – 30.*
Ilodibia, C. V., Chukwu, A. J., Akachukwu, E. E., Adimonyemma, R. N., Igboabuchi, N. A. and Ezeabara, C. A. 2016. Anatomical, Proximate, Vitamin and Mineral Studies on *Piper guineense* (Piperaceae) *International Journal of Plant & Soil Science 11(1): 1-6, 2016; Article no.IJPSS.25385*
Jigam AA, Helmina O, Dauda BEN, Okogun JO, 2010. Polygalloyltannin isolated from the root of Acacia nilotica Del. (Leguminoseae) is effective against Plasmodium berghei in mice. *Journal of Medicinal Plants Research 4(12): 1169 – 1175.*
Mbongue F. G., Kamtchouing P., Essame O. J., Yewah P M, Dimo T, Lontsi D. (2005). Effect of the aqueous extract of dry fruits of *Piper guineense* on the reproductive function of adult male rats. *Indian Journal Pharmacol*. 37:30-32
Negbenebor,C.A; Godiya,A.A; Igene,J.O (1999). Evaluation of Clarias anguillains treated with spice of P. *guineense* for washed mice and Kama book type product, Food composition Anal, 2:12-315.
Nwachukwu C. U., Ume N. C., Obasi M. N., Nzewuihe G. U. and Onyirioha C. (2010), The Qualitative Uses Of Some Medicinal Plants In Ikeduru L.G.A Of Imo State, Nigeria, *New York Science Journal*, issue 3, vol.11, p.132.
Ogunlesi, M., Okiei, W., Azeez, L., Obakachi, V., Osunsanmi, M. and Nkenchor G. (2010). Vitamin C contents of tropical vegetables and foods. Determined by volt-ammetric and titrimetric methods and their relevance to the medicinal Uses of the Plants. *International Journal of Electrochemical Science 5:105 – 115.*
Okonkwo, C. and Ogu, A. 2014. Nutritional Evaluation of Some Selected Spices Commonly Used in the South-Eastern Part of Nigeria. *Journal of Biology, Agriculture and Healthcare Vol.4, No.15.*
Okwute, S.K (1992). Plant derived pesticidal and antimicrobial agents for use in Agriculture. A review of phytochemical and biological studies on some Nigerian plants. *J. Agricul. Sci. Technol*, **2**(1): 62 – 70.
Olawuyi, E.B., Osikabor, B. and Aderounmu A. F. 2013. Effects of *Piper guineense* (Schumach) seeds extract on the control of insect pest of *Amaranthus viridis* (LINN). *Journal of Forestry Research and Management. Vol.10, 83-92.*
Sumathykutty M. A, Rao J. M, Padmakumari K. P, Narayanan CS (1999), Essential Oil Constituents Of Some Piper Species, *Flavors Fragr. Journal*, issue 14, pp. 280-281. Uhegbu, F. O., Imo, C. and Ugbogu, A. E. 2015. Effect of Aqueous Extract of Piper Guineense Seeds on Some Liver Enzymes, Antioxidant Enzymes and Some Hematological Parameters in Albino Rats. *International Journal of Plant Science and Ecology Vol. 1, No. 4, 2015, pp. 167-171*

Utilization Potential of *Gliricidia sepium* (Jacq.) Kunth ex.AND *Azadirachta indica* A. Juss Wood in Lamp Holder Production

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ABSTRACT

Physical properties and natural durability of lamp holder produced from two different wood species (Gliricidia sepium and Azadirachta indica) were investigated. Two wooden souvenirs were produced each from off-cuts using dimension of 101.6 x 101.6 and 76.2x 203.2 inches. The physical properties of the wood samples such as moisture content, specific gravity and radial shrinkage, tangential shrinkage, volumetric shrinkage were determined using standard procedures. The moisture content of the wood species was 6.73 and 11.2 for Azadirachta indica and Gliricidia sepium respectively. Azadirachta indica had mean value of 0.92 while Gliricidia sepium had mean value of1.33.Radial shrinkage for Azadirachta indica and Gliricidia sepium was 5.77% and 9.23% respectively while tangential shrinkage was 3.37% and 8.39% respectively. The volumetric shrinkage was9.15% and 17.62% for Azadirachta indica and Gliricidia sepiuin respectively. Statistical analysis showed that there was no significant difference between the termite and fungi attack on wood species used after sixteen weeks of exposure. Based on the result obtained from the parameters assessed in the study, it can be deduced that both Gliricidia sepium and Azadirachta indica are all technically suitable for production of lamp holder.

Keywords: Construction, Utilization, *Gliricidia sepium, Azadirachta indica*

INTRODUCTION

Wood is hard, fibrous structural tissue found in the stems and roots of trees and other woody plants. It has been used for hundreds of thousands of years for both fuel and as a construction material (Cook, 2000; Ambe, 2001).Wood has been found to be an important raw material that contributes significantly in improving the country's economic base, industrialization and comfort of the teaming population. It is still considered indispensable and highly demanded in spite of many substitute materials-like iron, plastic, concrete and steel (Wood, 2006). These substitutes have not always being successful because of their difficulties in matching the versatility and intrinsic properties of wood as a natural engineering material. The inherent properties of wood such as easy workability, gluability and high strength have led to the perpetual interest and demand of wood and its products.

As the world population increases, the demand for wood and wood products also increases as a result of over exploitation of both natural and plantation forests hence, the problem of deforestation. Deforestation has been a long standing problem facing the forestry sector. This is due to the fact that more trees are harvested from the forest estate without being replaced and fully utilized (Badejo, 2001). Utilization of wood though an indispensable activity of man has many shortcomings because most sawmills especially in Nigeria have low conversion efficiencies due to unavailability of good equipment in the conversion processes. Studies have shown that the conversion efficiency of sawmill in Nigeria is in the range of 40-56% (Fuwape, 2008). As a result of sawing or conversion, wood waste or residue like slabs, off-cut, sawdust, edging and defected parts of wood are produced. These wood wastes constitute 44-60% of the logs input (Badejo and Giwa, 2001). The disposal of these wastes is usually done by burning which is injurious to human, therefore constituting to problems of the environment (Omole *et al.*,2009).

However, most people are not aware that wood wastes are not just waste but can be managed judiciously to produce items that can be useful for everybody. For instance, *Azadiracta indica* and *Gliricidia sepium* wood are not just there as lesser known timber species (LKTS) but it can be used for construction of agricultural implement (Ogbogu, 1990; Ajala, 2014). Increasingly, the forest is losing its status as the sole producer of solid wood for construction and other structural, economical and domestic application (Omole *et al.,* 2005). According to (Omole and Adetogun, 2010) it is therefore important to study quality of some wood waste within our environment and the durability of these species to determine their potential as lamp holder among other uses.

It has been reported that less than two third of the harvested tree is finally taken away from the forest for further processing (FAO, 2000). In addition, Ajayi, (2002) stated that only about 50-55% of the harvested wood becomes marketable after processing in sawmill. This indicates that large quantity of wood waste is generated during wood processing.

The introduction of lesser known timber species (LKTS) to the market will expand the resources and make a lot more materials available to the timber industry while taking some of the pressure off the primary species as noted by Appiah *et al.* (1998) and Addae-Mensah (1998). However, Ayoka (1998) looked at the importance of LKTS from economic point of view and said that increasing their utilization will generate more job opportunities, introduce new technologies in wood processing, and boost the construction and housing delivery activities. Efforts should be made at finding ways to utilize some of the wood that has been left as waste (Franz, 2001). The studies to utilize lesser known wood species for the production of wooden lamp holder will create another market for lesser known wood species, therefore adding to economic of wood.

Azadirachta indica (Neem) A. Juss is an evergreen tree growing in almost every state of India where it has been used for centuries for medicinal purpose, pest management and also well for construction (Mulholland *et al,*2000). Neem has acclimatized well throughout Northern Ghana and is popular as a source of fire wood and as poles and rafters for building construction as well as provision of shade. *Gliricidia sepium* (Jacq.) Kunth ex. is the most widely used cultivated multipurpose tree that has been used in many parts of the tropics for fuel wood, live fences, fodder, soil improvement, construction like agricultural implement (Ajala, 2014).

The main objective of the study is to assess the utilization potential of *Azadirachta indica* and *Gliricidia sepium* wood species, being lesser known specie usedwith a view of determining their physical and biological properties for the production of lamp holder.

MATERIALS AND METHODS

Sample Selection and Collection

The off-cut of the wood species *(Azadirachta indica* and *Gliricidia sepium)* used for this study were obtained from Federal College of Forestry, Ibadan. The adhesive (top bond) was purchased at Ogunpa market, Ibadan while the machinery and technical support were provided in the Carpentry and wood workshop unit at FRIN.

Conversion Process

The woodspecimen were converted to the standard size of 20 x 20 x300mm in thickness, breadth and length in accordance with British Standard BS 373 (2001). They were oven-dried at 103±2 ºC to attain 8-12% moisture content prior to adhesive application and bonding processing. This was done a week prior to testing for physical properties in order to prevent possible dimensional changes as a result of loss of moisture from wood.

Bonding Process

The adhesive glue was spread on the wood, paired and glue together following an arrangement of the wood. Treated wood samples were clamp together with holding device (clamp) for the period of 72 h at room temperature.

Production process

After the bonding process, the laminated woods were smoothened by the use of sand paper so as to remove unwanted materials. The laminated wood samples were placed on the wood lathe for turning operation. After the turning operation on the wood lathe, the produced lamp holders were smoothened using the rough and smooth sand paper. The lamp holders produced were then sprayed using spraying machine.

Determination of physical properties

Physical properties determine in this study include: moisture content, specific gravity, shrinkage and natural durability of wood samples.

Determination of moisture content (MC)

The test specimens were oven dried at 103±2°C f to a constant weight and their moisture content were determined in accordance with British standard BS 373(1989).The wood species of *Azadirachta indica* and *Gliricidia sepium* were replicated four (4) times. The MC was calculated according to equation 1

$$\%MC = \frac{Wi-Wo}{Wo} \times 100 \quad \text{..... (1)}$$

Where.
MC = Moisture content
Wi = Weight of specimens before oven drying
Wo = weight of specimen after oven drying.

Determination of percentage shrinkage

Test specimens 2cm x 2cm x 4cm were used for determination of shrinkage. They were soaked in water for 48 hours (2days) in order to get them conditioned to moisture above fibre saturation point. Specimen was removed one after the other and were measured using digital veneer calipers. Percentage shrinkage along the two planes was measured after specimen had been oven dried using this formula.

$$S = \frac{Ds-Do}{Ds} \times 100 \quad \text{.....(2)}$$

Where,
S = Shrinkage %
Ds = Dimension at saturation condition
Do = Dimension at oven dry condition

Determination of Specific Gravity

The specimen for specific gravity (SG) was obtained by removing cubes of 2cmx2cmx2cm from each specimen. They were subjected to a gravimetric procedure developed by Smith (1954) in which specimens were completely saturated with water by boiling from initial moisture content. Each cube was removed from the water, blotted to remove excess water, weighed and oven dried to a constant weight at 103 ± 2ºC. Specific gravity was then determined using the equation 3.

$$SG = \frac{1}{\frac{Ws-Wo}{Wo} + \frac{1}{1.53}} \quad \text{.....(3)}$$

Where,
SG =Specific gravity
Ws = Saturated weight of wood
Wo = Oven dry weight of wood
1.53 = Constant weight of wood substance developed by Smith (l954)

Determination of Weight Loss

Weight loss method was then used to evaluate the decay resistance of the wood species against the wood-rotting basidiomycetes after sixteen weeks of exposure to fungi and termite in accordance with Zabel and Morrell (1993); Adetogun and Adegeye (2000);Ajala (2014). Durability test against *Azadirachta indica* and *Gliricidia sepium* was carried out in accordance with EN113 (1996) using wood blocks. The wood blocks were oven dried at 103±2 ºC until a constant weight is obtained. The weight obtained immediately after this process was taken as W_1.The wood species were subjected to termite and fungi without using preservatives so as to determine the natural durability of wood species. After sixteen weeks the test blocks were carefully removed from Petri dishes and grave yard and were cleaned with dry cotton and weighed (W_3). The weight loss was determined using the equation 4 according to AWPA (1997).

$$\%WL = \frac{W1-W3}{W1} \text{ x } 100 \text{.....(4)}$$

Where,

% WL= Percentage Weight Loss
W_1 = Oven dry weight of wood
W_3 = Weight of wood after exposure

EXPERIMENTAL DESIGN AND DATA ANALYSIS

The values obtained from this study were subjected to statistical analysis and the statement of significance was based on P≤0.05. Duncan Multiple Range Tests was used to separate the means.

RESULTS AND DISCUSSION

Physical Characteristics of the Selected Wood Species

The results of some physical properties (moisture content, shrinkage and specific gravity) of the *Azadirachta indica* and *Gliricidia sepium* are presented in Table 1.

Table 1: Mean Values of Physical Properties of *Azadirachta indica* and *Gliricidia sepium*

Physical properties	*Azadirachta indica*	*Gliricidia sepium*
Moisture content (MC %)	6.73	11.24
Radial shrinkage (RS %)	5.77	9.23
Tangential shrinkage (TS %)	3.73	8.39
Volumetric shrinkage (VS %)	9.51	17.62
Specific gravity (SG)	0.59	0.78

Specific gravity

The mean values for specific gravity of the sampled species were0.59 and 0.78 for *Azadirachta indica* and *Gliricidia sepium,* respectively. PROTA (2016) reported a range of 0.72 – 0.93 at 12% moisture content for the specific gravity of *A. indica*. Poku *et. al*., (2001) in their work on lesser-known species from Ghana recorded 0.28, 0.34and 0.69 from *Ricinodendron heudelotti, Alstonia boonei* and *Petersianthus macrocarpus* respectively. Chudnoff (1980) got a range of 0.40-0.48 when working on*Aningeria robusta***,** a lesser-known species while Okai (2003) recorded avalue of 0.50 for *Aningeria robusta* from Ghana. Age and location could have contributed to the slight differences. The variation in this study may arise as difference in sampling position, age and ecological zones.

Gliricidia sepium with a specific gravity of 0.78in this study is in accordance with the report of PROTA (2016) who reported a value of 0.75 but at variance with that of EOL (2016) who reported a range of 0.53-0.64, while Glover, (1989) also reported a range of 0.5-0.8.The variance could have been attributed to age of tree, site, climate, geographical locations of sampled trees noted Poku*et. al.,* (2001).Statistically, there was no significant difference. This implies that dimension of the samples to produce lamp holder has no effect on the specific gravity test. However, Osadare, (2001) noted that specific gravity is the best single index that determine the quality of wood. The high specific gravity demonstrated by *G. sepium* confirmed the statement credited to T.H (2008) that it is being used for furniture, turnery and artisanry because of its strength, while (Glover, 1989) attached it uses to agricultural implements, timber and poles because of the same reason.

Radial Shrinkage

The radial shrinkage recorded in this study are 5.77% and 9.23% respectively from *A. indica and G. sepium.* Similar studies by Poku *et al.,* (2001) for other lesser-known species reported 2.51% for *Alstonia boonei* and 4.01% for *Petersianthus macrocarpus.* The result of analysis of variance conducted for *Azadirachla indica* and *Gliricidia* shows that there is no significance difference. The variance is related to the rapid reduction of microfibrilar angle, age of trees as well as the geographic location.

Tangential Shrinkage

The mean value for tangential shrinkage was 3.73% for *A. indica* and 8.39% for *G. sepium.Poku et al. (2001)* recorded a mean value of 4.4%, 6.8% and 4.0% for *Alstonia boonei,Petersianthus macrocarpus*and *Ricinodendron heudelotti*being lesser-used hardwoods from Ghana. Ajala, (2006) also observed a mean value of 1.35% with a range of 0.89-3.42% in his work on *Aningeria robusta* from Nigeria. The disparity could be adduced to the environmental factors affecting the sampled tree
s.

Volumetric Shrinkage

The values for the volumetric shrinkage of the species as given indicated that *Azadirachta indica* had 9.51% while *Gliricidia sepium* had 17.62%.Chudnoff (1980) recorded a mean value of 11.8% from *Aningeria robusta* from Ghana while Ajala (2006) recorded a mean value of 2.41% from the same species being lesser-used from Nigeria. The wide disparity

could have been attributed to age of trees, geographical location and probably presence of more biomass in latewood cells. The values obtained for shrinkage are pointer to the fact that the species are will not be affected much by weather variation there by resulting in warping, checking, splitting and other seasoning defects.

Percentage Weight Loss for Termite Attack

The percentage weight loss of *Azadirachta indica* and *Gliricidia sepium* is presented in Table 2. Weight loss of termite attack on *Azadirachta indica* (6.34%) was higher than the value obtained for *Gliricidia sepium* (1.32%).This implies that higher percentages (93.6% and 98.68%) of the wood species were still intact unaffected by the nibbling of the termite. This indicated the natural durability of the species to withstand termite attack if used for lamp holder.
The percentage weight loss of the *Azadirachta indica* for white rot and brown was 5.66% and 4.41%, respectively while for *Gliricidia sepium* was 9.46 and 9.05% respectively. Statistically there is no significant difference at 0.05 levels. The values obtained for both termite and fungi reflected the assertion of Glover (1989) and T.H. (2008) that the species is hard and durable while Craig and John (2006), Scheffer and Morrell (1998) and Duke (1983) reported that it is very resistant to insects, termites and fungi. These clearly indicated that the two species possess natural durability to withstand attack from the two fungi strains if turned into lamp holders.The lamp holder produced from *Azadirachta indica* and *Gliricidia sepium* are shown in plate 1 and 2 respectively.

Table 2: Mean Value of Natural Durability Assessed for Wood Species used

	Percentage Weight loss		
	Termite (%)	White rot (%)	Brown rot (%)
Azadirachta indica	6.34	5.66	4.41
Gliricidia sepium	1.32	9.46	9.05



Plate 1: Wooden Lamp Holder Produced from *Azadirachta indica*



Plate 2: Wooden Lamp Holder Produced from *Gliricidia sepium*

CONCLUSION AND RECOMMENDATION

Production of lamp holder was successfully carried out in this study using two lesser known wood species. The study assessed selected physical properties and the result obtained revealed that the wood species have improved physical properties and natural durability.

Based on the parameters assessed from this study, it can then be recommended that wooden souvenirs produced from these species can be used for interior decoration which may serve as substitute for plastic and some other breakables in terms of durability and strength.

Attention should be focused on how to manage and conserve the forest resources in order to reduce the shortage of available wood to industry and utilization of wood waste for the production of effective, profitable and viable products such as wooden lamp holder will reduce the pressure mounted on the existing forest.

REFERENCES

Addae-Mensah, A. (1998): Industrial utilization and improved marketing of some Ghanian lesser-used timber species from sustainable managed forests. In International Conference on Value-added Processing and Utilization of lesser used timber species proceedings Kumasi, Ghana Pp. 44-49.

Adetogun, A. C. and Adegeye, A. O. (2000): Evaluation of Cashewnut Shell liquid (CNSL) as a wood preservative. *The Bioprospector* 2: 85-102.

Ajala, O. O. (2006): Evaluation of the Physical and Mechanical Properties of *Aningeria robusta* A. Chev. M. Phil. Thesis at the Department of Forest Resources Management, University of Ibadan. Pp. 137.

Ajala, O. O. (2014): Potentials of Heartwood Extract of *Gliricidia sepium* (Jacq.) Steud as preservative against Wood–Decaying *Lentinus sajor-caju* and *Trichoderma viride.* Ph.D. Thesis, Department of Agriculture and Forestry, University of Ibadan, Ibadan. Pp. 192.

Ajayi, B (2002): Wood waste management of forest industries paper presented at ODSG-FAN Consult workshop on forest industries Environment and Sustainable development, Akure 28-29. Nov.2001. *Journal of Tropical Forest,* pp 6.

Ambe, K (2001): Structure of timber design (Napier University) pp 26.

Avoka K. B. (1998): some mechanical properties of untreated jute fibre reinforce polyster composite. *Journal of applied science and manufacturing 30 (3): 277-284.*

Badejo, S.O. and Giwa S.A. (2001): Dimensional stability of cement bonded boards manufactured with coffee chaff. *Journal of the Korean Wood Science and Technology*. In Nigeria Technical Report No 50. Forestry research institute of Nigeria, Ibadan.

Chudnoff M. (1980): *Tropical Timbers of the World*. Agricultural Handbook No. 607, USDA Forest Services, Forest Products Laboratory, Madison.

Cook 2000: Wood handbook. Wood as an Engineering Material. USDA72. Washington pp466.

Craig, R. E. and John, K.F. (2006): *Gliricidia sepium*. Species Profiles for Pacific Island Agroforestry www.traditionaltree.org. April 2006. Pp18 (Retrieved 03/10/2010)

Duke, J. A. (1983): *Handbook of Energy Crops*. Unpublished

EN 113 (1996): Wood Preservatives- Test Method for determining the protective effectiveness against wood destroying basidiomycetes- determination of toxic values. European Committee for Standardizations (CEN), Brussels, Belgium. 31p

Encyclopedia of Life (EOL) (2016): *Gliricidia sepium*–Overview-Encyclopedia of Life. www.eol.org./pages/642632ove (Retrieved 03/09/2016)

FAO (2000): Forestry: statistic today for tomorrow, Rome, 52p.

Fuwape, J. (2008): A physical and mechanical properties of plantation grown wood species in Nigeria. *Journal of Science Technology.* Vol.10 (1) pg.22-36.

Glover, N. (1989): Gliricidia production and use. Nitrogen Fixing Tree Association, Waimanalo, Hawaii, USA. 44PP

Mulholland, D. A., Panel, B., Coombes, P.H. (2000): The chemistry of the meliaceae and pteraxylaceae of Southern and Eastern African and Madagascar.*Curr.Org. Chem.*4.1011-1054

Ogbogu, G.D. (1990): "Problems associated with the use of wood in building Construction in Nigeria and possible solutions". *Proceeding of 26th annual conference of Forestry association of Nigeria.*

Okai, R. (2003): Characterization of moisture content and specific gravity of branch wood and stem wood of *Aningeria robusta and Terminalia ivorensis. Holz als Roh-und Wrekstoff* 61:155-158

Omole, A. O. and Adetogun ,A. C. (2009): Utilization potentials of *Eucarlyptus grandiso* (Hill Books) a multicipal tree of the university of Ibadan campus. *Research Journal of the Applied Sciences.pp.675*

Omole, A. O. and Adetogun, A. C. (2010): Dimensional properties of wood cement panels Produced from wasteof some Trees species in university of Ibadan. *Forest and forest products Journal.* Pp5-9.

Osadare, A. O. (2001): Basic Wood and Pulp Properties of Nigerian-grown Caribbean Pine (*Pinus caribaea* Morelet) and their relationships with tree growth indices. Ph. D Thesis at the University of Ibadan. Pp. 417.

Poku, K., Wu Q. and Vlosky R.(2001): Wood Properties and Their variations within the tree stem of lesser-used species of tropical hardwood from Ghana. *Wood and Fiber Science 33: 284-291.*

PROTA (2016): *Gliricidia sepium* (Jacq.) Kunth ex. www.prota4u.org/protav8 (Retrieved 03/09/2016)

Scheffer, T.C. and J.J. Morrell (1998): Natural Durability of Wood: A Worldwide Checklist of Species. Forest Research Laboratory, Oregon State University. Research Contribution 22. 58pp http://owic.oregonstate,edu/pubs/durability.pdf (Retrieved 27/08/2009)

Smith, D.M. (1954): *Maximum Moisture Content Method for Determining Specific Gravity of Small Wood Samples.* USDA Forest Service, Forest Products Laboratory, Madison.

Wood (2006): Relation of strength of wood to duration of load. *U.S for prod. Lab.rep. no 1916. Madison wise. pp. 46*

Zabel, R. A. and Morrell, J. J. (1993): Natural decay resistance: Wood durability; Decay and its Prevention: *Wood Microbiology.* Pp. 399-411

Characterizing within-and between-tree patterns of variation and distribution of tracheid morphology in *Pinus caribaea* Morelet grown in Afaka, Nigeria

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ABSTRACT

The wood properties of three 26 years old Caribbean pine established in trail plot at Afaka Forest Reserve were randomly selected and destructively sampled at breast height (1.3m), 25% and 50% of total tree height. The within-, between trees and interaction were analyzed for variations in tracheid length and diameter. The wood morphologies were studied separately for the earlywood and latewood to yield the lowest variances in the pine. The tracheids length was done by maceration in equal volume (1:1) of 10% acetic acid and 30% hydrogen peroxide. The distribution of the tracheid length was described by two parameter Weibull probability density function and adjudged by the Kolmogorov Smirnov values. The analysis of variance revealed that the between sampled trees, within tree (DPH position) and their interactions had a significant effect on the tracheid length and diameter at probability level of p < 0.05% for earlywood and latewood. The mean values of the tracheid length decreases along the disc position from the base to the top of the tree except for tree two that increases at 25% of the tree height for earlywood while generally, the diameter increases with height up to 25% before it was decreasing. The Coefficient of variation values decreases in increasing axial direction up to 25% of the tree height for Tree 1 and 2 before decrease set in at 50% of the total tree height. The Weibull two parameter probability density functions are the likely model for modeling the tracheid length of these Pinus species. Though, the tracheid length at breast height and 25% of the pine height appears more evenly distributed than at 50%, this might be as a result of shrinkage in volume with increasing tree height. Variations in the distributions of the wood properties are considered to vary largely between the earlywood and the latewood of the sampled trees. Most of the overall variations of the pine species were as a result of the within tree variations.

Keywords: Wood morphology, Caribbean pine, Weibull distribution, within- and between tree variations.

INTRODUCTION

Caribbean pine *(Pinus caribaea* Morelet*)* is one of coniferous exotic tree species that has been introduced to Nigeria. The establishment of pine plantations across many parts of the country was to meet the increasing demand for long fibre pulp for the productions of different paper and paper board products. The genus *Pinus* is composed of about 95 species native to the New World (North and South America) and the Old World (Eurasia and Northern Africa) (Kiaei, 2011). The suitability of a tree species for papermaking depends solely on its density and tracheid or fibre morphology. Fibre length usually does not directly contribute to density, but is an important descriptor factor of pulp quality, given its relationship with paper strength properties (Mansfield and Weineisen 2007, Ek *et al.*, 2009). The most important fibre dimensions are length, width, lumen diameter and wall thickness (Irbe *et al.*, 2013). The ecological conditions of a place usually affect the anatomical structure of woody cells such as tracheid length, vessels diameter, parenchyma proportion and lumen thickness. These in turns, with the genetic make-up have bearing on strength and quality of pulp and paper products that would be produced. In conifers, increased growth rate usually leads to a greater increase in earlywood (low density) than in latewood (high density) formation and also delays the transition from juvenile wood to mature wood (Zhang *et al.*, 1996; Koga *et al.*, 2002). According to Pallardy (2008), wood properties are affected by earlywood to latewood ratio. Considering that the fiber strength is not constant even with uniform length and diameter, understanding the distribution of the tracheid is pertinent in ensuring the reliability of such materials for designing good wood paper and paper board products. However, information about the variations of many of the tracheid dimension of pine wood (Habibi *et al.*, 2003), mechanical properties (Kiaei, 2011), wood properties (Udoakpan, 2013) and rotation age (Oluwadare, 2007) has been documented. It is necessary to investigate some of the wood quality parameter of these coniferous tree species to provide useful information for the pulp yield and properties as well as gain Knowledge on the future prospect of the species. The objectives of this study were: (a) to investigate the variations in the patterns of tracheid length and diameter in the radial and axial

directions as well as their interrelationships. (b) to investigate the tracheid length distribution and frequency using two parameter Weibull distribution for the axial direction.

MATERIALS AND METHODS

Wood samples of *Pinus caribaea* (Morelet) used for the study were obtained from 26-year-old-tree plantation grown in Afaka Forest Reserve, Nigeria. This reserve, is a guinea savanna reserve located in Kaduna at latitude 10^0 7′ N and longitude $7^0$17′ E at an altitude of 600m above sea level. Its mean annual rainfall is about 1300 mm with daily minimum and maximum temperatures of 18°C and 24°C, respectively. From the sampled area, three trees of good vigor and straight bole were randomly selected for destructive sampling methods to study tracheid length, cell wall thickness, diameter and lumen thickness along the stem height and across the radial cross-section. From each tree, stem sectional discs of 5cm in thickness were obtained at different levels of total height (breast height (1.3m), 25% and 50%) to study radial and axial variation in selected properties. Wood splints of approximately 20 mm X 2 mm were obtained from earlywood and latewood tracheids and macerated in equal volume (1:1) of 10% acetic acid and 30% hydrogen peroxide after the method of Franklin, (1945). The bleached and soft splints were washed thoroughly in water and shaken in aqueous ethanol solution to free the tracheids. Two slides were prepared for each ring sample and 20 tracheids measured in swollen condition using Rheichart visopan microscope for length (mm), diameter (µm), lumen width (µm), and cell wall thickness (µm) at X 40. From these, the derived morphological characteristics viz: felting power (FP) = tracheid length / diameter; coefficient of flexibility (F) = lumen diameter/ diameter; and wall fraction (WF) = 2*cell wall thickness / diameter were determined.

STATISTICAL ANALYSIS

Analysis of variance tools of STATISTICA 7.0 was employed to test the statistical significance of variation in the trees radial and axial (sampling height) directions for the tracheid length measured in the three trees. Fisher's Least significant difference (LSD) (Steel and Torrie, 1980) was used to test the statistical significance at $\alpha = 0.05$ levels. The commercial spreadsheet package of EasyFit 5.5 professional was used to describe the two parameter Weibull probability density function of the tracheid length $(f(x)) = \alpha/\beta\ (x/\beta)^{\alpha-1} \exp(-(x/\beta)^{\alpha})$. Where x is the tracheid length, α is the scale parameter and β is the shape parameter that describes the spread of the distribution. Excel spread sheet was used in producing the graphs. The frequencies of the histogram were obtained by dividing the data into bins and the probability density function categories into the binned data set to count the frequencies.

RESULTS AND DISCUSSION

Morphological Characteristics in the Wood Properties

Separation into earlywood (EW) and latewood (LW) classes was proposed to yield the lowest variances in raw material (Havimo *et al.,* 2009, Havimo, 2010). Tables 1 and 2 showed the descriptive statistics for the mean and coefficient of variation of anatomical and morphological tracheid properties of *P. Caribaea* earlywood and latewood respectively. Each one of the variables was measured at different sections along the axial and radial directions. The annual growth rings from the pith to bark for the three trees sampling heights were recorded for the radial direction. Statistical analyses indicated that these variations were mostly significant along the direction. However, the radial variation trends from the pith to bark for the tracheid length and diameters were generally in an ascending order. The axial and radial variation for the tracheid length and diameter (EW and LW) are shown in Figures 1(a - d) and Figure 2 (e - h).

Tracheid Length

The highest and the lowest values of tracheid length were 8.04 mm and 1.1 mm for earlywood and 8.2 mm and 1.4 mm for latewood, respectively. Form the earlywood statistics as shown in Table 1, the mean value of the tracheid length decreases along the disc position from the base to the top of the tree except for tree two that increases at 25% of the tree height. On average, there was small axial variation pattern for the earlywood tracheid length (Figure 1(a)) with a slight decrease towards the top, while in Tree 2 an increase to the 25% level was noted followed by a decrease. The radial variations were generally in an ascending order as shown in Figure 2a and vary also along the sampling disc height. The rate of increase trends to be more rapid in early age of 1 to 9 corresponding to the juvenile wood zone. Thereafter, the rate of increase was gradual from the 10^{th} to 17^{th} growth rings, which represents the later part of the juvenile period to transition age. From the 18^{th} growth ring to the 26^{th} growth ring there was leveling off depicting the mature zone. The least minimum mean value and coefficient of variation (COV) was recorded for tree three at 50% (middle) of total tree height. Generally, the COV decreases in increasing axial direction up to 25% of the tree height. For the latewood tracheid description statistics as shown in Table 2, its minimum and maximum mean value and COV was recorded for tree three at 50% (middle) of total tree height respectively. The tracheid length latewood axial and radial variation also follows similar patterns like that of the earlywood as shown in Figure 1(b) and Figure 2(f) respectively. Generally, the variations for both EW and LW increased radially from the pith to the bark and axially along sampling height in the Pinus species

across the tree levels. The differences in the coefficient of variation values as revealed in the tables further indicate the heterogeneity among the trees.

Table 1: Wood physical properties statistics along sampling height for each tree (Earlywood)

DPH	Wood properties	N	Tree 1	Tree 2	Tree 3
1.3m	Tracheid Length (mm)	520	4.51(0.2552)	4.82(0.2978)	4.39(0.2415)
	Diameter (µm)	520	77.16(0.1585)	76.30(0.1459)	71.40(0.1349)
	Lumen Thickness (µm)	520	61.09(0.1981)	59.58(0.1778)	53.38(0.1844)
	Double Cell Wall Thickness(µm)	520	16.03(0.1742)	16.69(0.1831)	18.03(0.2086)
	Felting power	520	58.06(0.1982)	62.57(0.2553)	61.90(0.2320)
	Flexibility coefficient (%)	520	78.67(0.0622)	77.78(0.0562)	74.39(0.0808)
	Wall Fraction (%)	520	42.58(0.2313)	44.36(0.1975)	51.29(12.126)
25%	Tracheid Length (mm)	440	4.48(0.2094)	5.19(0.2620)	4.15(0.2365)
	Diameter (µm)	440	78.25(0.4555)	81.59(0.1264)	75.65(0.1343)
	Lumen Thickness (µm)	440	59.68(0.1584)	65.20(0.1532)	59.75(0.1602)
	Double Cell Wall Thickness(µm)	440	16.80(0.1824)	16.39(0.1696)	15.96(0.2061)
	Felting power	440	58.45(0.2028)	63.15(0.2294)	54.69(0.1967)
	Flexibility coefficient (%)	440	77.52(0.0867)	79.65(0.0491)	78.78(0.0576)
	Wall Fraction (%)	440	44.25(0.2078)	40.70(0.1921)	42.59(0.2131)
50%	Tracheid Length (mm)	360	4.47(0.2421)	4.81(0.2868)	4.03(0.2116)
	Diameter (µm)	360	75.68(0.1412)	76.93(0.1479)	75.92(0.1445)
	Lumen Thickness (µm)	360	60.19(0.1718)	60.97(0.1854)	61.54(0.1726)
	Double Cell Wall Thickness(µm)	360	15.70(0.3115)	15.95(0.1588)	14.42(0.2301)
	Felting power	360	58.86(0.2077)	62.02(0.2339)	52.82(0.1538)
	Flexibility coefficient (%)	360	79.28(0.0551)	78.85(0.0545)	80.79(0.0618)
	Wall Fraction (%)	360	41.89(0.2732)	42.29(0.2038)	38.58(0.2564)

Where; DPH = disc position along sampling heights; N = sampling number,
Value in parenthesis ( ) = Coefficient of variation

Lumen thickness and Diameter

The lumen thickness in EW and LW tracheid ranged from 16.0 µm to 97.6 µm and from 8.0 µm to 68 µm respectively. It as a minimum mean value of 53.38 and 22.05µm and Maximum mean value of 65.20 µm and 28.97µm for EW and LW, respectively. The diameter on average was 76.47 µm and 55.05 µm for EW and LW respectively. The mean values of the diameter increases up 25% of the disc sampling height before decrease sets in except for Tree 3 that increases at 50% sampling disc height for EW. Similar results were also recorded for the LW except for Tree 2 that increases at 50% sampling disc height. These is also supported with the axial position graph as shown in Figure 1(c-d) for EW and LW respectively. Detailed descriptive on the trees sampled and disc position heights are shown in Tables 1 and 2. The pattern of radial variation of the diameter corresponded to increase from the pith to the bark for the earlywood as shown in Figure 2(g). Similar pattern was also observed for the latewood

although with an initial decrease in ring 2 as shown in Figure 2(h). These radial variations are inherent to cambial ageing as the tree grows in diameter. The EW diameter contains an outlier which may be due to error in recording.

Table 2: Wood physical properties statistics along sampling height for each tree (Latewood)

DPH	Wood properties	N	Tree 1	Tree 2	Tree 3
1.3m	Tracheid Length (mm)	520	4.66(0.2506)	5.01(0.2611)	4.81(0.2137)
	Diameter (µm)	520	55.16(0.1382)	55.54(0.1139)	51.52(0.1258)
	Lumen Thickness (µm)	520	24.88(0.2542)	22.05(0.3626)	24.84(0.2409)
	Double Cell Wall Thickness(µm)	520	30.28(0.2083)	33.49(0.2123)	26.66(0.1929)
	Felting power	520	84.21(0.2144)	89.97(0.2384)	94.02(0.2077)
	Flexibility coefficient (%)	520	45.05(0.1993)	39.38(0.3124)	48.02(0.1817)
	Wall Fraction (%)	520	109.90(0.1623)	121.23(0.2030)	103.90(0.1693)
25%	Tracheid Length (mm)	440	4.60(0.2131)	5.45(0.2314)	4.48(0.2093)
	Diameter (µm)	440	55.94(0.1164)	58.18(0.1069)	53.92(0.1467)
	Lumen Thickness (µm)	440	26.10(0.2401)	23.63(0.5033)	28.91(0.3189)
	Double Cell Wall Thickness(µm)	440	29.77(0.2080)	34.92(0.2208)	24.95(5.977)
	Felting power	440	82.42(0.1923)	94.31(0.2322)	84.58(0.2400)
	Flexibility coefficient (%)	440	46.59(0.2051)	40.33(0.5235)	52.85(0.2277)
	Wall Fraction (%)	440	106.56(0.1804)	120.92(0.2200)	94.15(0.2597)
50%	Tracheid Length (mm)	360	4.68(0.2110)	5.05(0.2630)	4.25(0.1856)
	Diameter (µm)	360	54.18(0.1234)	58.20(0.1266)	53.43(0.1184)
	Lumen Thickness (µm)	360	23.37(0.2366)	27.50(0.4092)	28.97(0.2779)
	Double Cell Wall Thickness(µm)	360	30.92(0.1941)	30.72(0.2634)	24.60(0.2672)
	Felting power	360	86.67(0.2022)	87.98(0.2690)	80.37(0.2037)
	Flexibility coefficient (%)	360	43.16(0.2094)	46.40(0.3125)	53.98(0.2422)
	Wall Fraction (%)	360	114.21(0.1647)	107.28(0.2716)	92.58(0.2716)

Where; DPH = disc position along sampling heights; N = sampling number,
Value in parenthesis ( ) = Coefficient of variation

Cell Wall Thickness

Cell wall thickness has a considerable effect on wood quality and this feature is greatly related to wood density (Butterfield *et al.*, 1993). The mean values of the cell wall thickness vary both within- and between trees species and may possibly due to site conditions and the genetic properties of the trees. The earlywood cell wall mean value decreases along the sampling disc height except for Tree 1 that increases at 25% sampling height. Similar result was also observed for the latewood Tree 3 while Tree 1 decreases up to 25% before increase set in. Cell wall thickness is known to be vital to pulp yield, fibre flexibility, coarseness and ease of collapsibility during refining of pulp (Oluwadare and Egbewole, 2008).

Flexibility Coefficient and wall Fraction

The wall fraction for the EW was generally below 50% while for the LW, they are slightly below and above 100%. The flexibility coefficient which shows the relationship between lumen thickness and diameter, has been described to be vital to paper strength especially during beating operations (Panshin and De Zeeuw, 1980). The flexibility coefficient was generally slightly below or above average for LW. The EW shows an increasing inter-tracheid bonding than the latewood. The least minimum flexibility coefficient for both EW and LW was recorded for Tree 3 at breast height (1.3 m). The differences in the flexibility coefficient mean value for the EW and LW may be as a result of the observable characteristics of the individual trees resulting from the interaction of its genotype with the environment. The latewood tracheid with higher cell wall thickness was more rigid than its earlywood counterpart. Therefore, minimization of latewood tracheid development may be an added advantage in plantation management.

Felting Power

For the felting power of the wood, the mean values vary for the EW and LW significantly from one other; there is no distinct pattern in its mean value. This implies that the felting power been exhibited by pinus species varies along the disc radius sampling height. The higher values obtained for latewood tracheid was as a result of the longer length of latewood than earlywood.

Within-- and Between-- trees and their Interactions

The results for the analysis of variance in Table 3 for earlywood tracheid length and diameter showed that the between sampled trees, within tree (DPH position) and their interactions are significantly different at probability level of $p < 0.05\%$. The result of the follow-up test as revealed by the LSD (Table 4) shows variation in the pattern of the tracheid length for between- and within trees for Tree 1 to 3, respectively. Similar variation was also observed for the within tree diameter. The variations in the diameter may probably be due to genetic factors and growth rate. There was no significant difference between the mean value tracheid length at 1.3m and 25% height of the wood. However, there was increase in the tracheid length of the earlywood up to 25% of the total tree at height before decrease set in. Similar trends was also shown by Muneri and Balodis (1998), where the tracheid length increased from the ground level to about 15% of tree height before decrease set in. The diameter of Tree 1 and 2 with mean value of 77.12 µm and 78.24 µm respectively were not significantly different from each other but are significantly different when compared with Tree 3. The variations in the between trees for the tracheid length and diameter may probably be due to genetic factors.

Table 3: Analysis of variance for tracheid length and diameter along sampling heights (within-), between trees and their interactions for earlywood

Wood properties		SS	DF	MS	F	p
Tracheid length	DPH	18.99	2	9.49	7.04	0.0009**
	Tree	370.04	2	185.02	137.28	0.0000**
	DPH*Tree	53.08	4	13.27	9.85	0.0000**
	Error	5324.85	3951	1.35		
Diameter	DPH	9098	2	4549	18.52	0.0000**
	Tree	10542	2	5271	21.46	0.0000**
	DPH*Tree	5762	4	1440	5.86	0.0001**
	Error	970659	3951	246		

significant at $p < 0.05\%$;** DPH = disc position along sampling heights

For their interactions, there was no significant difference in the pattern of variation in the tracheid length for Tree 1 across all the sampling height of the disc. At 25% and 50% of the total sampling height, Tree 3 shows no variation in the pattern of the tracheid length. Similar results were also observed at 1.3m and 50% for Tree 2. The implication of these is that, the little decrease in the mean tracheid length along the tree height from the base to the top is not consistent for all tree species. The diameter interactions variation pattern is a little beat different from that of the tracheid length. Details of these are presented in Table 4. Ivkovich *et al.*, (2002) proposed that the differences in the heritability of tracheid characteristics that determine ring width may come from different regulatory processes.

Table 4: LSD for interactions between- and within trees for earlywood

DPH	Tree No	Tracheid length mean(mm)	Diameter mean(µm)
50%	3	4.0266[b]	75.9200[a]
25%	3	4.1493[b]	75.6473[a]
1.3m	3	4.3915[a]	71.3985[c]
50%	1	4.4694[a]	75.6756[a]
25%	1	4.4770[a]	78.2455[b]
1.3m	1	4.5072[a]	77.1569[ab]
50%	2	4.8108[c]	76.9311[ab]
25%	2	5.1900[d]	81.5927[d]
1.3m	2	4.8213[c]	76.3031[ab]

Mean with the same letters are not significantly different

The analysis of variance for latewood as shown in Table 5 is similar to the results of earlywood for the sampled trees, within tree (DPH axial position) and their interactions. There is variation in the pattern of the tracheid length of the LW for the between trees and within trees (disc sampling height) at probability level of $p < 0.05\%$. The mean value of the tracheid length increases up to 25% tree height with no significant difference between the mean value at 1.3m and 25% height of the wood. The diameter are significantly different from each other both at the within- and between trees level with the diameter increasing up to 25% before decrease set in. The variation within trees (DPH) may have a significant effect on the use of wood and definitely have influence on food and water transportation of the tree. Adenaiya *et al.,* 2016 noted that the between-tree variation observed in the anatomical properties may prove advantageous in tree breeding programmes.

Table 5: Analysis of variance of tracheid length and diameter along sampling heights (within-), between trees and their interactions for latewood

Wood properties		SS	DF	MS	F	P
Tracheid length	DPH	24.21	2	12.10	9.84	0.0001**
	Tree	307.08	2	153.54	124.82	0.0000**
	DPH*Tree	101.56	4	25.39	20.64	0.0000**
	Error	4860.19	3951	1.23		
Diameter	DPH	2749	2	1375	29.25	0.0000**
	Tree	12218	2	6109	130.00	0.0000**
	DPH*Tree	1595	4	399	8.49	0.0000**
	Error	185669	3951	47		

significant at $p < 0.05\%$;** DPH = disc position along sampling heights

Table 6 show the Fisher's Least significant difference (LSD) for the interactions between- and within trees in the latewood. The diameter at 25% and 50% of the total sampling height for Tree 3 and at 50% total height for Tree 1 are not significantly different for one another. There is much variation in the tracheid length as observed from the LSD results in Table 6. For instance, the within tree variation are significantly different from one another for Tree 3. These affirm the statement of Zhang *et al.,* (1994) that major portion of the variability often observed is within the trees themselves.

Table 6: LSD for interactions between- and within trees for latewood

DPH	Tree No	Tracheid length mean(mm)	Diameter mean(µm)
50%	3	4.254944[e]	53.4267[a]
25%	3	4.484500[a]	53.9164[a]
1.3m	3	4.814808[c]	51.5200[d]
50%	1	4.680722[ac]	54.1844[a]
25%	1	4.604682[ab]	55.9364[b]
1.3m	1	4.661808[a]	55.1615[b]
50%	2	5.051000[d]	58.1956[c]
25%	2	5.454227[f]	58.1764[c]
1.3m	2	5.005154[d]	55.5446[b]

Mean with the same letters are not significantly different

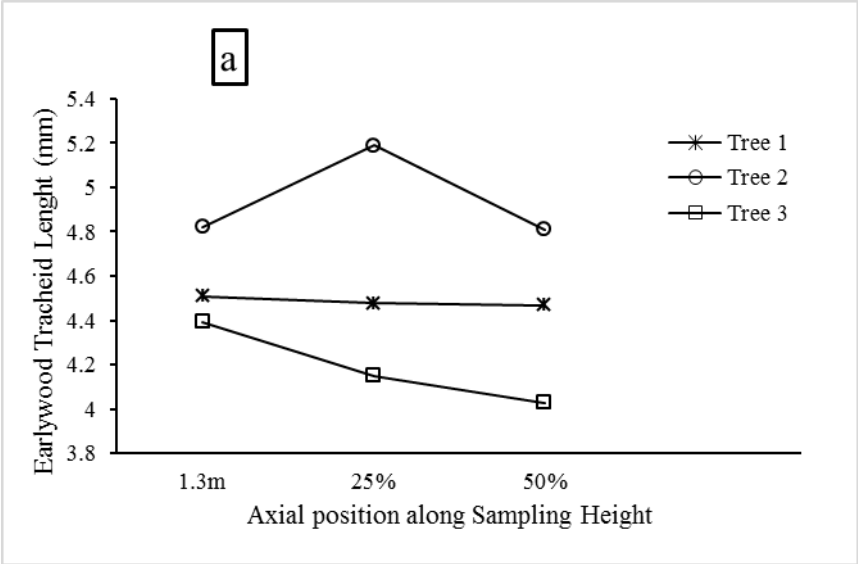
Tracheid Length Pattern of Variation and Distribution in Axial Direction

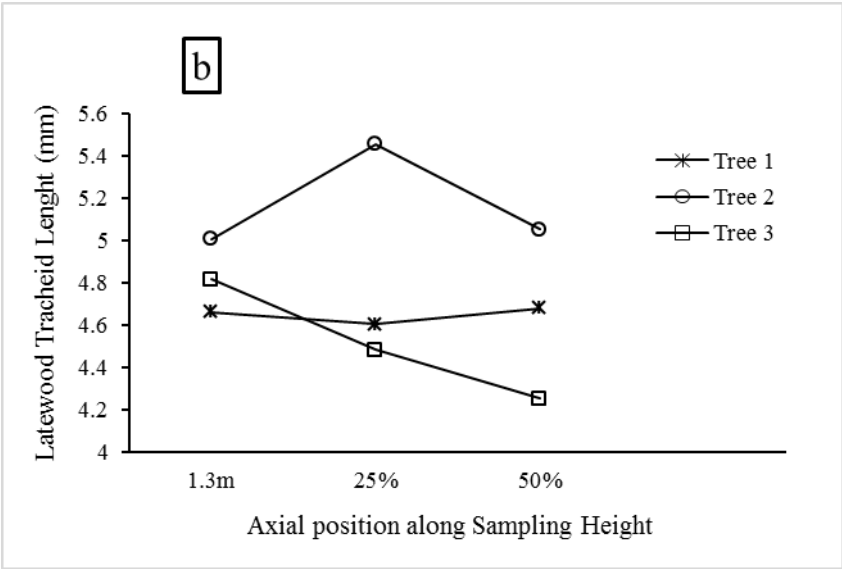
Figures 3 - 4 showed the within tree histogram and the tracheid length distribution for the three disc sampling height (1.3m, 25% and 50%) of the total tree height. It can be clearly seen that the tracheid length distribution is not homogeneous within the Caribbean pine sampling height for the EW and LW respectively. The LW and EW distributions were quite similar. Generally, the tracheid length measured at breast height appears to have a longer tail towards higher values of the tracheid length for all the sampled trees when compared with the other disc position sampling height for both EW and LW. The distribution of the tracheid length at breast height and 25% of the pine height appears more evenly distributed than at 50%, this might be as a results of shrinkage in volume with increasing tree height. For all the within tree sampling height, it was observed that there is decreased in the tracheid quality and strength with increasing length. The implication of these is that longer tracheid length on an average will tends to have a lower strength when compared with shorter tracheid length. The Weibull parameters estimates are showed in details in Table 7. Generally, the scale and shape parameter are fairly closed to each other and when judged by the Kolmogorov Smirnov (K-S) test value, they yielded the lowest value. The distribution can well describe a random variable. Although the K - S test valve is relatively small when compare to other distributions (graph not shown), it does not implies that the Weibull probability distribution is the most reasonable one but that the Weibull probability density function is the most likely model for modeling the tracheid length of these Pinus species because other test values like Anderson Darling and Chi-Squared also yielded the lowest value although, values not shown.

Table 7: Goodness of fit and Parameter Estimate for the Tracheid Length

	DPH		Kolmogorov Smirnov	α (scale)	β (shape)
Tree one	1.3m	**Earlywood**	0.08522	3.9644	4.9888
	25%		0.10925	5.2168	4.8633
	50%		0.08784	4.2866	4.9164
	1.3m	**Latewood**	0.06927	4.1809	5.1373
	25%		0.06927	4.1809	5.1373
	50%		0.07691	5.2733	5.0793
Tree two	1.3m	**Earlywood**	0.14546	3.3045	5.3991
	25%		0.12679	3.7382	5.772

	50%		0.08488	3.6139	5.3435
	1.3m	**Latewood**	0.11525	3.8861	5.547
	25%		0.09767	4.4045	5.9967
	50%		0.09582	3.7692	5.6095
Tree three	1.3m	**Earlywood**	0.05486	4.9857	4.773
	25%		0.1041	4.5692	4.5446
	50%		0.14495	4.7259	4.4106
	1.3m	**Latewood**	0.06706	5.4863	5.2087
	25%		0.07838	5.2578	4.8684
	50%		0.13839	5.6116	4.6077
Combined	1.3m	**Earlywood**	0.04793	3.9955	5.0495
	25%		0.07383	4.2895	5.0614
	50%		0.06900	4.1282	4.8878
	1.3m	**Latewood**	0.05778	4.4359	5.2986
	25%		0.04751	4.7723	5.2923
	50%		0.06841	4.6644	5.0994


a
5.4
5.2
5
4.8
4.6
4.4
4.2
4
3.8
Earlywood Tracheid Lenght (mm)
1.3m
25%
50%
Axial position along Sampling Height
Tree 1
Tree 2
Tree 3


b
5.6
5.4
5.2
5
4.8
4.6
4.4
4.2
4
Latewood Tracheid Lenght (mm)
1.3m
25%
50%
Axial position along Sampling Height
Tree 1
Tree 2
Tree 3

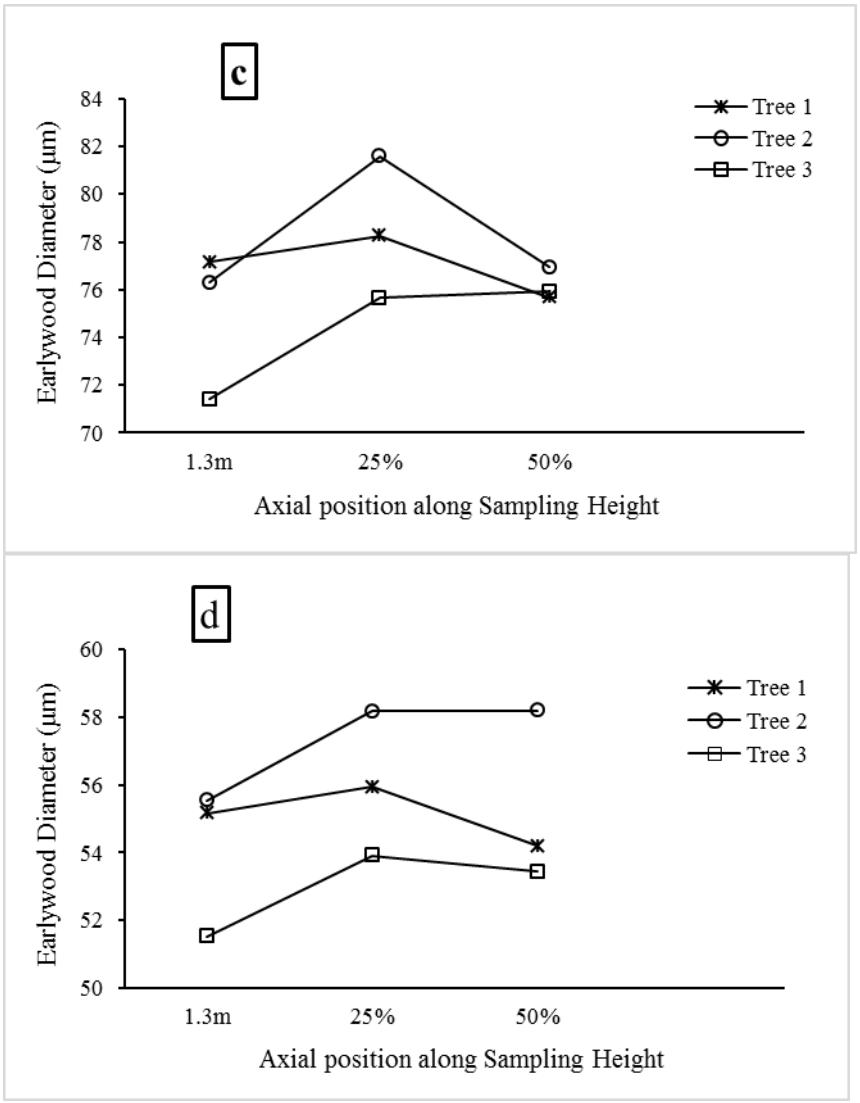
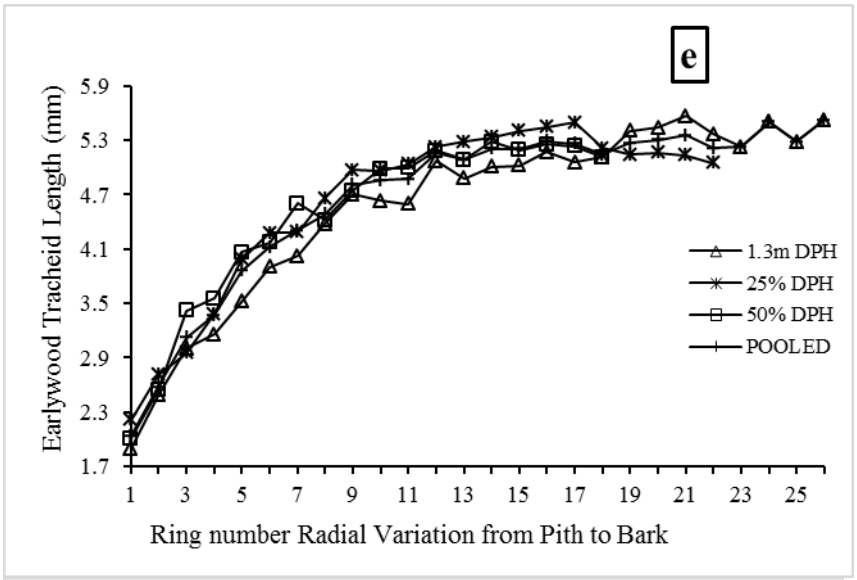
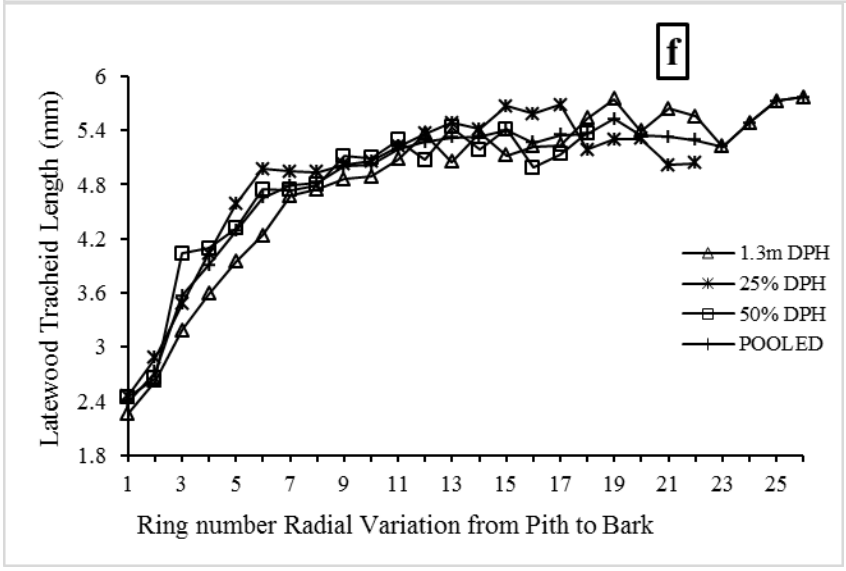


Figure 1 (a -d): Axial variation in earlywood and latewood tracheid length and diameter


e
Earlywood Tracheid Length (mm)
5.9
5.3
4.7
4.1
3.5
2.9
2.3
1.7
1 3 5 7 9 11 13 15 17 19 21 23 25
Ring number Radial Variation from Pith to Bark
1.3m DPH
25% DPH
50% DPH
POOLED


f
Latewood Tracheid Length (mm)
6
5.4
4.8
4.2
3.6
3
2.4
1.8
1 3 5 7 9 11 13 15 17 19 21 23 25
Ring number Radial Variation from Pith to Bark
1.3m DPH
25% DPH
50% DPH
POOLED

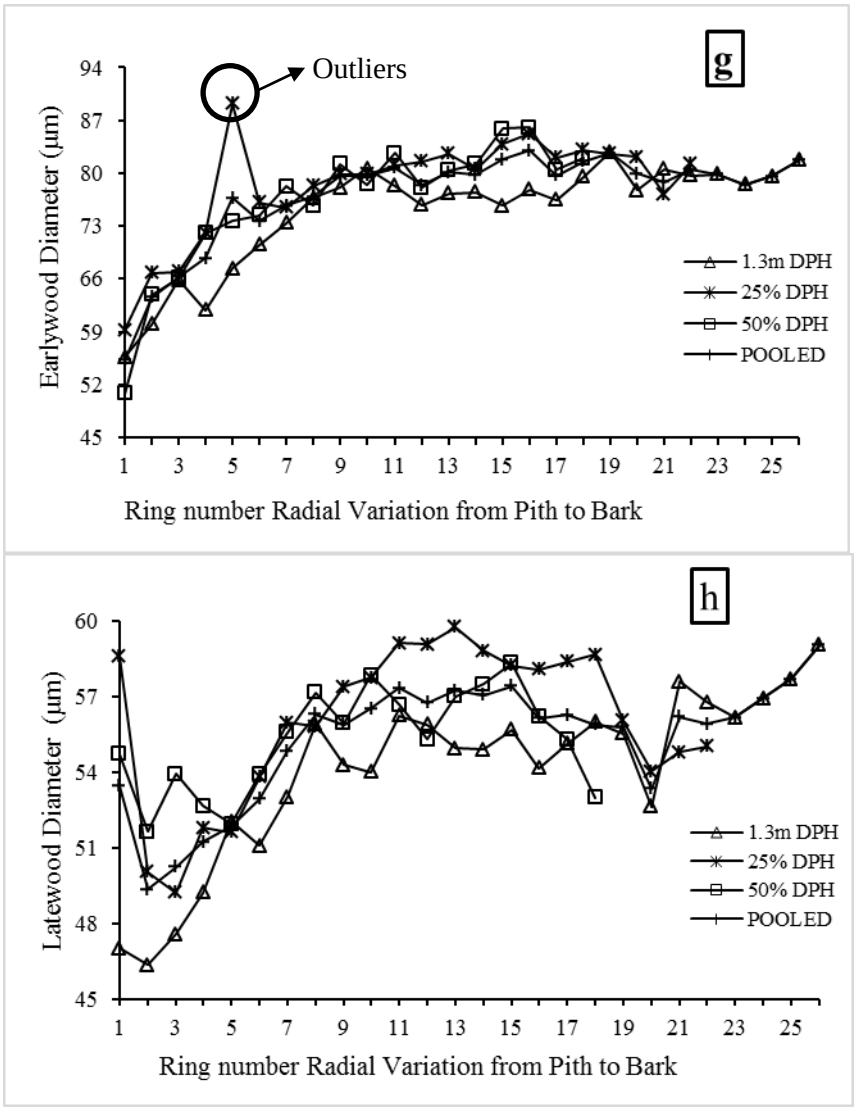
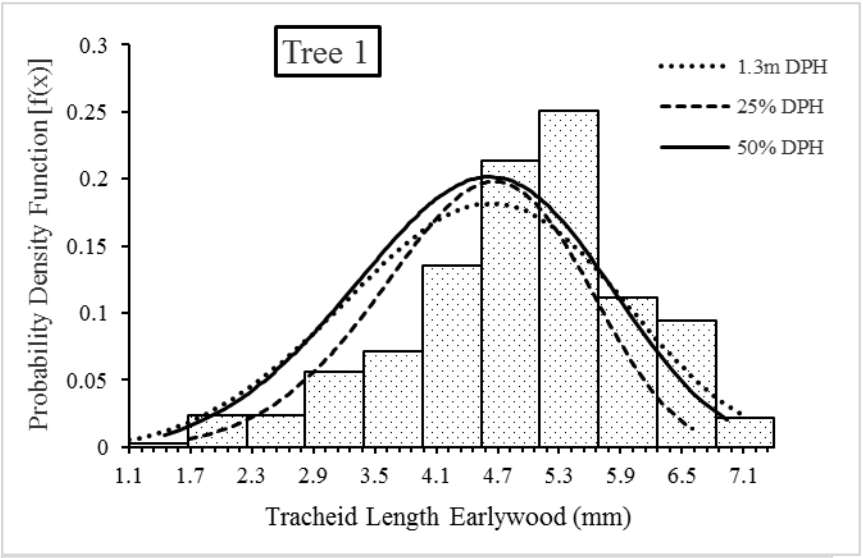
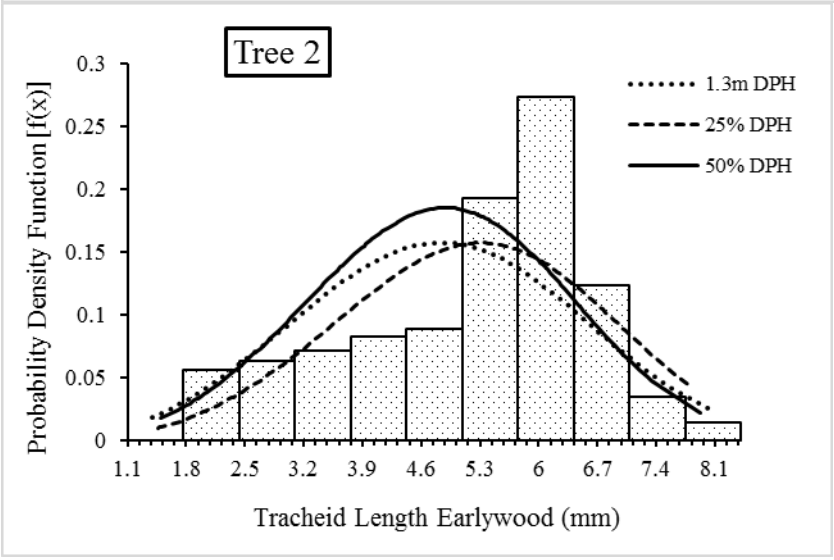


Figure 2 (e - h): Pooled radial variation in Tracheid length and diameter in 26-years-old *Pinus caribaea*


Tree 1
1.3m DPH
25% DPH
50% DPH
Probability Density Function [f(x)]
0.3
0.25
0.2
0.15
0.1
0.05
0
1.1 1.7 2.3 2.9 3.5 4.1 4.7 5.3 5.9 6.5 7.1
Tracheid Length Earlywood (mm)


Tree 2
1.3m DPH
25% DPH
50% DPH
Probability Density Function [f(x)]
0.3
0.25
0.2
0.15
0.1
0.05
0
1.1 1.8 2.5 3.2 3.9 4.6 5.3 6 6.7 7.4 8.1
Tracheid Length Earlywood (mm)

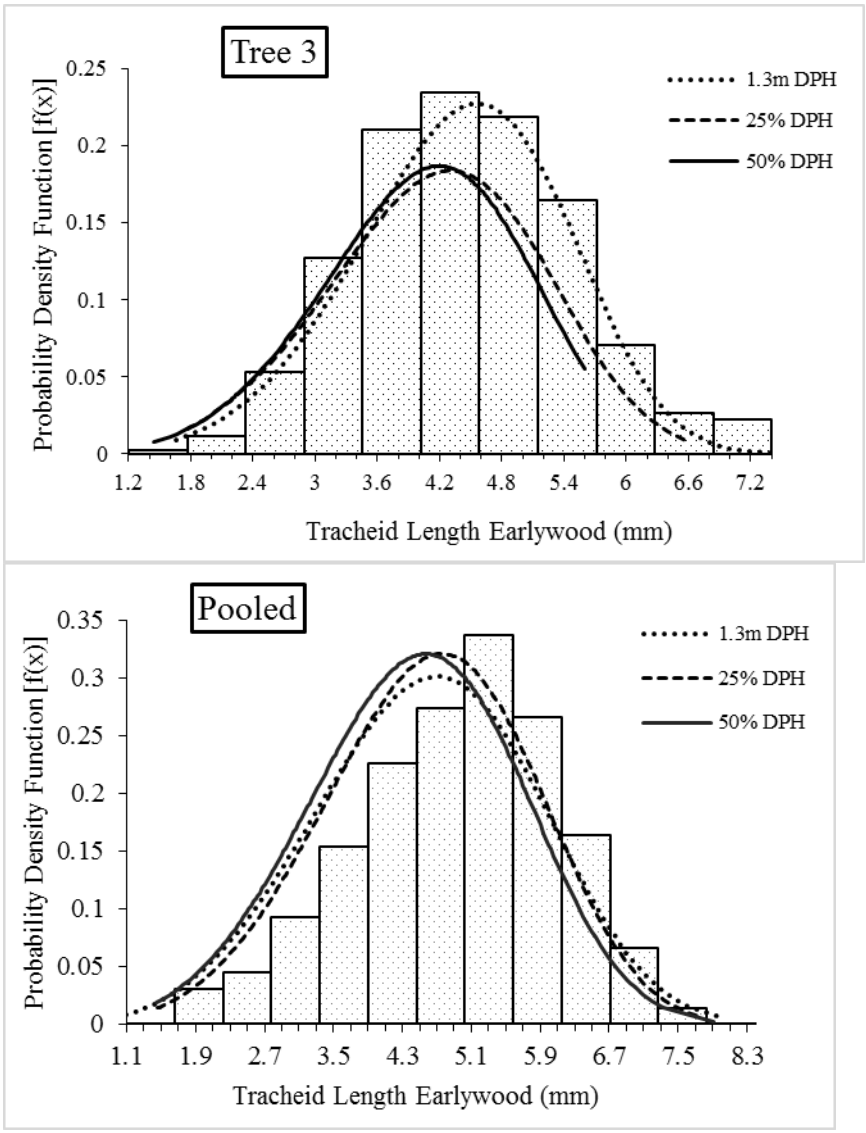
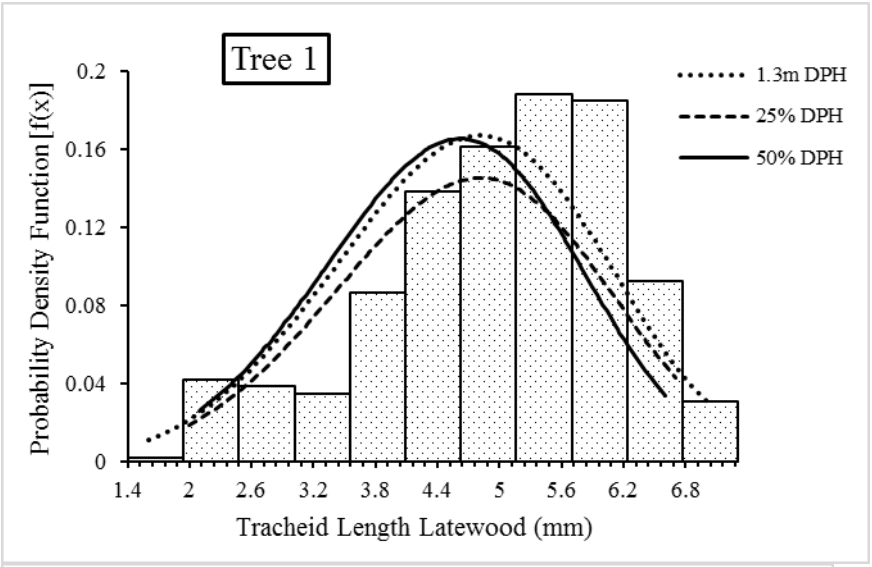
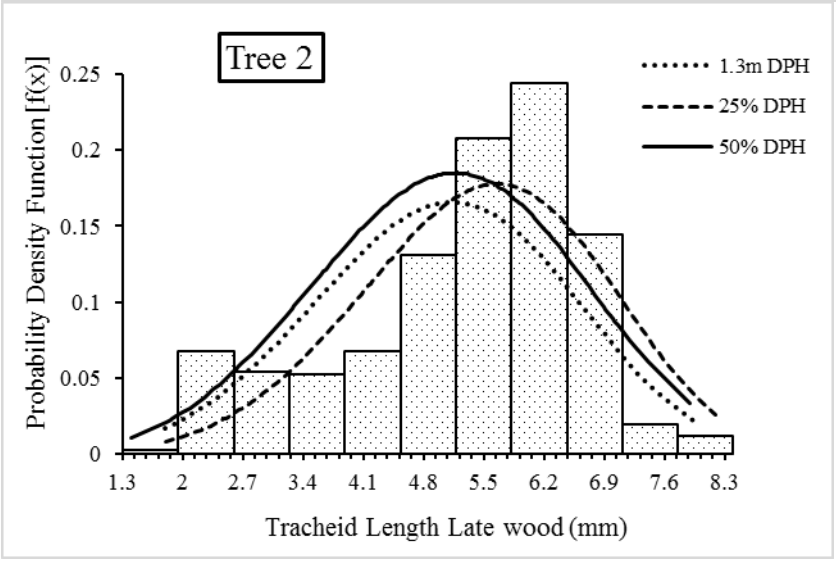


Figure 3: Earlywood Tracheid Length Weibull Distribution, Pattern of Variation and Histogram in Axial Direction


Tree 1
1.3m DPH
25% DPH
50% DPH
Probability Density Function [f(x)]
0.2
0.16
0.12
0.08
0.04
0
1.4
2
2.6
3.2
3.8
4.4
5
5.6
6.2
6.8
Tracheid Length Latewood (mm)


Tree 2
1.3m DPH
25% DPH
50% DPH
Probability Density Function [f(x)]
0.25
0.2
0.15
0.1
0.05
0
1.3
2
2.7
3.4
4.1
4.8
5.5
6.2
6.9
7.6
8.3
Tracheid Length Late wood (mm)

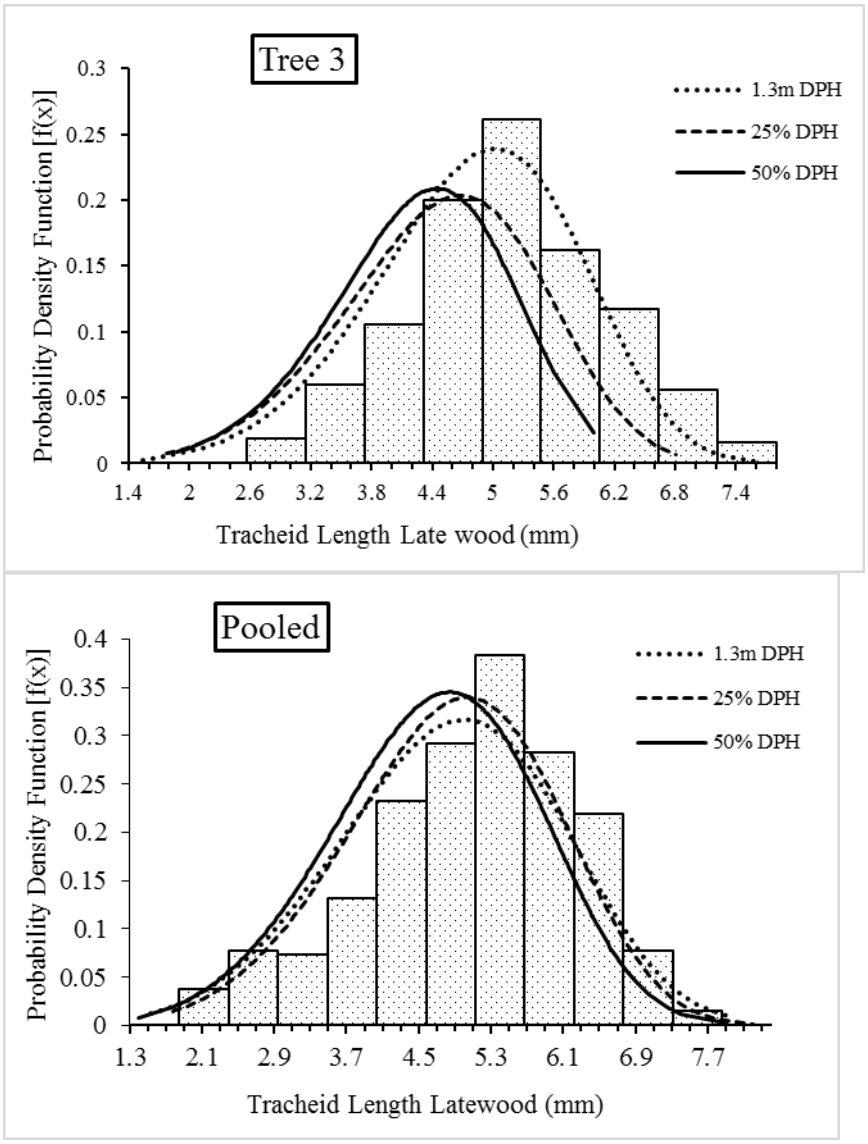


Figure 4: Latewood Tracheid Length Weibull Distribution, Pattern of Variation and Histogram in Axial Direction

CONCLUSION

The three Caribbean pine species used in these study for the within-, between trees and their interactions had a significant effect on the tracheid length and diameter. It is concluded that within the trees, the stiffness and shrinkage properties varies. These properties were found to vary largely between the earlywood and the latewood of the sampled trees both along radial and axial directions. Most of the overall variations of the pine species was as a results of the within axial and radial tree variations. It is considered that the tracheid length of the Caribbean pine will definitely affects the quality of the wood that will be produced. The Weibull probability density function was found useful in describing the distribution of the tracheid length showing the growth responses and rates of cell production. The tracheid length is not homogeneously distributed within the Caribbean pine sampling height for the EW and LW respectively although, the values of the parameters along the sampling height shows the largest variation. The scale and shape parameters can be used to model variations in strength properties of the Caribbean pine at a given tracheid length. Therefore, it is pertinent to consider the distribution and properties of wood natural fibers for good production of papers and paper board products.

REFERENCES

Adenaiya A. O., and Ogunsanwo O. Y. (2016). Radial Variation in Selected Physical and Anatomical Properties Within and Between Trees of 31 Year Old *Pinus caribaea* (Morelet) Grown in Plantation in Nigeria. *South-east European Forestry* 7 (1): 49-55.

Franklin, G. L. (1945). Preparation of thin selection of synthetic resins and wood-resins composites and a new macerating method for wood. *Nature* 155: 3924-3951.

Habibi M. R., Hossinzadeh A., Jahan-Latibari A., Familian H., and Hossinkhani H. (2003). Investigation on trend of tracheids variations of *Pinus eldarica*. *Iranian Journal Wood Paper Research* 16: 73-92.

Havimo, M. (2010). Control of tracheid cross-sectional dimensions in Norway Spruce and Scots pine wood raw materials. *Scandinavian Journal of Forest Research 25 (5):462 – 469.*

Havimo, M., Rikala, J., Sirvio, J. and Sipi, M. (2009). Tracheid cross-sectional dimensions in scots pine (*Pinus sylvestris*) – distributions and comparison with Norway spruce (*Picea abies*). *Silva Fennica* 43 (4):681 - 688.

Irbe, I., Sable, I., Treimanis, A., Jansons, A. and Grinfelds, U. (2013). Variation in the Tracheid Dimensions of Scots Pine (*Pinus sylvestris* L.) and Lodgepole Pine (*Pinus contorta* Dougl. var. *latifola* Engelm) tress Grown in Latvia. *Baltic Forestry* 19 (1): 120 – 127.

Ivkovich, M., Namkoong, G. and Koshy, M. (2002). Genetic variation in wood properties of interior spruce. II. Tracheid characteristics. *Canadian Journal of Forest Research* 32: 2128-2139.

Kandeel, E. S. A. E. and Bensend, D. W. (1969). Structure, density and shrinkage variation within a silver maple tree. *Wood Science* 1:227-37.

Kiaei Majid (2011). Anatomical, physical, and mechanical properties of eldar pine (*Pinus eldarica* Medw.) grown in the Kelardasht region. *Turk Journal for Agriculture & Forestry* 35: 31-42

Koga S., Zhang S.Y., and Begin J. (2002). Effects of precommercial thinning on annual radial growth and wood density in Balsam fir (*Abies balsamea*). *Wood Fiber Science* 34: 624-645.

Muneri, A., and Balodis, V. (1998). Variation in wood density and tracheid length in *Pinus patula* grown in Zimbabwe. *South African Forestry Journal* 182, 41-50

Oluwadare A. Oluwafemi (2007). Wood Properties and Selection for Rotation Length in Caribbean Pine (*Pinus caribaea* Morelet) Grown in Afaka, Nigeria. *American-Eurasian Journal Agriculture & Environmental Science.* 2 (4): 359-363.

Oluwadare A. O. and Egbewole Z. T. (2008). Wood Quality Studies in Plantation-Grown Sterculia (*Sterculia setigera* Del.) in the Guinea Savanna, Nigeria. *Research Journal of Forestry* 2 (1): 22 - 33

Pallardy, S. G. (2008). Physiology of woody plants. Academic Press imprints of Elsevier, USA, Uk, 464 pp.

Panshin A. J. and De Zeeuw, C. (1980). Textbook of wood Technology. McGraw-Hill, New York, pp: 772.

Raymond, C. A., Banham, P., and Macdonald, A. C., (1998). Within tree variation and genetic control of basic density, fiber length, and coarseness in *Eucalyptus regnans* in Tasmania. *Appita Journal*. 51(4): 299-305.

Steel, R. G. D., and Torrie, J. H. (1980). Principles and procedures of statistics, a biometrical approach. 2nd edition McGraw-Hill, New York, NY. 633 pp

Udoakpan U. I. (2013). An evaluation of wood properties of *Pinus caribaea* (Morelet) in Oluwa forest reserve, Ondo State, Nigeria. *Ethiopian Journal of Environmental Study Management* 6 (2): 159-169

Zhang S.Y, Simpson D., and Morgenstern E. K. (1996). Variation in the relationship of wood density with growth in 40 black spruce *(Picea mariana*) families grown in New Brunswick. *Wood Fiber Science* 8: 91 - 98.

Bio-ActiveProperties of *Murraya paniculata* (Linn.) Jack Plant

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ABSTRACT

Murraya paniculata is grown in Nigeria for aesthetics whereas, the medicinal value of the plant is yet to be exploited. It has been shown that the plant possesses many medicinal uses. This study was designed to determine the bioactive properties of M. paniculata plant. Leaves, bark and roots were collected from a single home grown tree at University of Ibadan. Samples were washed, air dried for 60days and ground into powdery form. From each component part, 100g of the powdered sample was extracted in 500mL of ethanol for 24 hours and allowed to stand at room temperature. Supernatant was carefully decanted, filtered and evaporated over water bath at 60°C. Solid extract obtained was used for yield determination of bioactive substances, phytochemical analysis, and FT-IR. Inhibitory zones of ethanolic extract and ampicillin were compared using clinical isolates of Escherichi coli and Staphylococcus aureus. Experimental design used was Complete Randomised Design. Data were subjected to descriptive statistics and ANOVA at $\acute{\alpha}_{0.05.}$ *Yield of bioactive compounds significantly differ from each other with leaves having 62.2%, bark 74.6% and root 67.6%, respectively. Tannin (0.050±0.001%) and cardiac glycosides (0.2103±0.001%) occurred only in the bark. Extracts from bark (27±0.58%), leaves (22.33±0.67%) and root (17±1.15%) significantly inhibited the growth of S. aureus and E. coli compared to that of Ampicillin (17±0.58%), (16±0.58%) and (16.33±0.33%). Chemical groups in the plant parts among others were alcohol, alkene, carboxylic acid and in different wavelength. Bioactive substances were more in the bark and more effective in inhibiting the growth of tested bacteria.*

Keywords: Pytochemical analysis, inhibitory property, FT-IR analysis, *Murraya paniculata*

INTRODUCTION

The use of plant has been in existence since ancient time as first-line treatment. Even, the greater part of the world's population in developing countries now rely on natural medicine which are often used as basic health service. Although, traditional medical methods were ignored due to some reasons of unknown toxicity of the plant, herbal dosage and the bioactive ingredients contained in the plant. This made people shy away from the use of traditional medicine. Recently, traditional medicine has become an important part of medicine. However, the interest and uses of medicinal plants have greatly increased in recent years and are now important sources for pharmaceutical manufacturing industry (Cox *et al*., 1994)

Murraya paniculata (L) Jack commonly known as orange jasmine is distributed throughout India to tropical and sub-tropical Asia and Africa. It can be grown as potted plants or cultivated as a bonsai.The leaves of *M. paniculata* contain spices that can be used to add flavor to foods, beverages and herbal medicines and spices can be used to cure, relax and excite human being to further influence their daily lives (Chomcalow, 1996). Bioactive compounds in plants are secondary metabolites produced by plants having pharmacological or toxicological effects. They contain chemical groups among them are Saponin, Tannin, Glycosides, Anthraquinone and Alkaloid (Aksel, 2010). However, *Murraya paniculata* has various chemical components isolated from different parts of the plant ranging from the roots, stem, bark and leaves. *M paniculata* have been known for many of its various pharmacological activities such as analgesic, anti-implantation, antinoiceptive, anti-feedant infertility, immunoreactivity, dysentery and stimulant (Li Q *et al.*, 1998 Rout *et al.*, 2007 and Sharker *et al.*, 2009). The objective of this study was to determine the bioactive substances in *M. paniculata* with the view to ascertaining its medicinal potentials since no research work has been carried out in this aspect in Nigeria.

MATERIALS AND METHODS

Plant parts such as fresh leaves, root and bark were collected within the University of Ibadan premises at Longitude 7°26′43.45″ N and Latitude 3°53′55.06″E.

Determination of bioactive component yield

The fresh leaves, root and stem were rinsed to remove dirt and air-dried at 27.3 °C with relative humidity of 62% and after which were ground using milling machine. The coarse powder was extracted with ethanol and allowed to stand at room temperature for 24hours. The solid extracts obtained were leaves 62.18g, bark 74.64g and root 67.62g, respectively.

Determination of anti-microbial activity

The solid extracts was then used to carry out chemical test such as phytochemical test using standard procedure to identify the constituents as described by Harbone (1973); Trease and Evans (1989) and Sofowora (1993). Selected tests carried out for phytochemical analysis were steroids, Terpenoids, chalcones, alkaloids, saponin, phenol and cardiac glycosides contents. After the bioactive compounds in the plant parts have been known and quantified the most appreciable bioactive compounds were then selected (alkaloids, phenol and saponnin) for antibacterial test. The clinical isolates used were *Staphyloccus aureus* and *Escherichi coli*, nutrient agar was melted and cooled to about 40-45 ^{o}C which was poured into different clean and sterile Petri-dishes. The agar plates were allowed to set and dried. It was later inverted into an incubator at 37 ^{o}C for 20minutes. The set agar plates were divided into six parts and labeled appropriately. The cork-borer was flamed, cooled and used to cut holes at the centre of each part and the plugs of agar were removed by a means of a flamed and cooled wire loops. This was repeated for each agar plate. The holes were then filled with known dilutions of the extracts, standard ampicilin and control. The plates were then left at room temperature at 37 ^{o}C for 18-24hours after incubation, diameter of zones of inhibition were measured and recorded.

Determination of Functional group

The powdered samples of *M. paniculata* were subjected to further test for its chemical characterization such as acids, alcohols, aldehydes, esters, ketones, sugars, phenols, guaicols, springols, furans, lignins derived phenols and extractible terepene using Fourier Transform-Infrared (FT-IR).

Data analysis

The experimental design used was completely randomized design and data was analyzed by means of One-way Analysis of Variance.

RESULTS AND DISCUSSION

Yield of bioactive substances in *Murraya paniculata*

The yield of bioactive substances obtained is presented in Table 1. The leaves of *M. paniculata* had the least yield of bioactive substances (62.18%) and closely followed by the root and bark with yield values of (67.62%) and (74.64%), respectively.

Table 1: Percentage yield of bioactive substances of *Murraya paniculata* parts.

	Leaves	Bark	Root
Initial weight(g)	431.57	274.33	159.50
Solid extract weight(g)	268.34	204.76	107.85
%yield	62.18	74.64	67.62

Phytochemical screening of *Murraya paniculata* plant parts

Table 2 indicated that alkaloids, saponin and phenol were present in appreciable amount in the leaves of *M. paniculata*; tannin and cardiac glycosides were also present in moderate amount while phlobatannin and anthraquinones were present in trace quantity. Flavonoids, steroids, terepenes, cardenolides and chalcones were absent. The bark contained alkaloids, tannin, saponin, chalcones and cardiac glycosides in appreciable amount while anthraquinones was found in moderate amount but flavonoids, steroids and terepenes were present in trace amount but cardenolides and chalcones were completely absent. However, in the root, alkaloids, saponin and phenol were present in appreciable amount; tannin and cardiac glycosides in moderate amount and phlobatannin in trace amount but flavonoids, anthraquinones, steroids, terepenes, cardenolides and chalcones were completely absent. As natural chemicals, they possess antioxidant or hormone-like actions used in prevention and treating of many health problems (Fransworth, 1990). Chakraborty and Brantner (1999) submitted that there is a linear relationship between alkaloid, saponin content and antibacterial activity as observed in the methanolic extract of stem and bark of *Holarrhena pubescens* for its antibacterial efficacy against *Staphylococcus aureus*. *Staphylococcus epidermidis*, *Streptococcus faecalis*, *Bacillus subtilis*, *Escherichia coli and Pseudomonas aeruginosa*. The crude ethanolic extract as observed from this study was active against all tested bacteria. Moreover, Tawaha *et al.,* (2007) studied the total phenolic content of selected Jordanian plant species and established that antioxidant activity was closely correlated with phenolic content.

Table 2: Phytoqualitative analysis of *M. paniculata* parts.

	LEAVES	BARK	ROOT
Alkaloids	+++	+++	+++
Tannin	++	+++	++
Phlobatannin	+	++	+
Saponin	+++	+++	+++
Flavonoids	-	+	-
Anthraquinone	+	++	-
Steroids	-	+	-
Terepenes	-	+	-
Cardenolides	-	-	-
Phenol	+++	+++	+++
Chalcones	-	-	-
Cardiac glycosides	++	+++	++

Keys: +++ appreciable amount, ++ moderate amount, + little amount, - absent

Anti-microbial activity of *Murraya paniculata* plant parts

Table 3 showed significant difference in the diameter of *E. coli* and *S. aureus* when treated with the various combination of root, leaves and bark extracts with ampicillin. The *S.aureus* had higher diameter values than *E. coli.* The higher the diameter, the higher the inhibitory activities of the organisms. Therefore, *S. aureus* would respond better than *E. coli* to any treatment involving the combination of any of the root, leaves or bark with ampicillin. The treatment with highest diameter was the bark extract and ampicillin (24mm) followed by the leaf extract and ampicillin (18mm) and root extract and ampicillin (14mm) against *E. coli* and in *S. aureus* the highest diameter was also the bark extract and ampicillin (27mm) followed by the leaf extract and ampicillin (22.33mm) and root extract and ampicillin (17mm). However, the activity shown against these organisms as observed in this study would appear to justify the effectiveness of the bark extract in treating infection such as gonorrhea, pneumonia and infection of the stomach or intestine better than ampicillin. According to Gautaum *et al.*, (2012) *M. paniculata* extract has been traditionally used as an antimicrobial medication and is believed to demonstrate significant antimicrobial activities. The leaves extract has been reported to be safe in its oral effective dose as it did not indicate toxicity when tested on rodents and at a concentration of 200mg/mL the inhibition zone of ethanolic extract and hydro-alcoholic extract tested on several human pathogenic bacteria, including *E. coil, K. pneumoniae*, S. *typhi*, *E. faecalis, P. aeruginosa*, S. *flexinerrii*, S. *aureus* and S. *sonneii* showed mild to moderate activity of 8-11mm. Thappa *et al*., (1996) studied the alkaloid content of *Adhatoda vasica* and reported two new alkaloid pyrroloquinazoline alkaloids, namely 1,2,3,9-tetrahydropyrrolo(2,1-b)-quinazolin-9-one-3R-hydroxy-3(2′-dimethylamino phenyl (desmethoxyaniflorine) and 7-methoxy - 3R – hydroxyl - 1, 2, 3, 9 - tetrahydropyrrolo - [2, 1 - b] – quinazolin - 9 - one (7 methoxyvasicinone) from leaves. likewise, Edeoga *et al*., (2005) isolated alkaloids from leaves of some Nigerian medicinal plants and evaluated their biological activities. They further stated that they tested the methanolic extract for its antibacterial efficacy against *Staphylococcus aureus, Staphylococcus epidermidis, Streptococcus faecalis, Bacillus subtilis, Escherichia coli* and *Pseudomonas aeruginosa*. The crude methanolic extract was active against all tested bacteria. Further chemical fractionation indicated that the antibacterial activity was mainly associated with the alkaloids

Table 3: Mean values of anti-microbial activity on plant parts

Treatment	Diameter of *E.coli*	Diameter of *S. aureus*
leaf extract and ampicillin	18.33^{a}	22.33^{a}
bark extract and ampicillin	24.00^{b}	27.00_{b}
root extract and ampicillin	14.00^{c}	17.00^{c}

Mean of three replicate samples. Values with the same alphabets are not significantly different at $\alpha = 0.05$ using

LSD test.

Result of FT-IR analysis of *Murraya paniculata*

Table 4 indicated the functional groups of the plant parts *M. paniculata* with their corresponding wave number (cm-1) and their class of compound as identified from FT-IR. The pharmaceutical application of alcohol includes blood fractionation or plasma, chemical intermediates, tableting, powders and antiboiotics. Amine important role in the survival of life – they are involved in the creation of amino acids, the building blocks of proteins in living beings. Serotonin is an important amine that functions as one of the primary neurotransmitters for the brain. It controls the feelings of hunger and is critical for the speed with which the brain operates in general. Carboxylic acid with the functional group of -COOH consist of group like citric acid which function as natural preservatives (E330 on food label), can be used to give fizzy drink effect in medicines like antacid stomach powder.

Table 4: Functional group of *M. paniculata* plant

Plant parts	Functional group	Absorbance(cm^{-1})	Class of compounds
Leaves	O-H	3411.88	Alcohols, phenols
	$=CH_2$	1632.13	Alkenes
	CH_3	1384.06	Alkanes
	C-N	1032.80	Amines
	N-H	688.76	Amines
Bark	O-H	3424.78	Alcohol, phenols
	$=CH_2$	1631.68	Alkenes
	O-C	1318.21	Carboxylic acids
	C=O	1032.88	Carboxylic acids
	N-H	663.28	Amine
Root	N-H	3419.73	Amine
	O-H	2920.45	Carboxylic acids
	O-H	2851.49	Carboxylic acids
	C=O	1737.39	Carboxylic acids
	C=O	1634.96	Carboxylic acids
	N-H	1511.85	Carboxylic acids
	CH_3	1383.81	Alkanes
	CH_3	1455.12	Alkanes
	O-C	1261.84	Carboxylic acids
	O-C	1034.28	Carboxylic acids
	S-S disulfide	536.31	Sulphur

Source: Field work (2015)

CONCLUSION

The percentage yield obtained from the various plant parts of the plant was appreciable; however, the percentage yield from the bark was greater than those obtained from leaves and roots. Alkaloids, Saponin and phenol were present in appreciable amounts within the various parts. So also, the FT-IR analysis indicates the presence of chemical compounds such as Alkanes, Alkenes, Alcohol, Amine, Sulphur and Caeboxylic in the various plant parts. The effect of ethanolic extracts of various plant parts significantly inhibited the growth of both micro-organisms compared to the ampicillin effect.

REFERENCES

Aksel Bernhoft 2008 (Ed). Bioactive compounds in plants- benefits and risks for man and animals. Proceedings of the Norwegian Academy of Sciences and Letters, 12-16.

Chakraborty, A, and Brantner, H .A (1999). Antibacterial steroids, alkaloids from the stem bark of *Holarrhena pubescens. J. Ethnopharmacol*., 68: 339-344.

Chomchalow N., (1996). Spice Production in Asia – An Overview.

Cox, P.A and Balick, M (1994). The ethno-botanical approach to drug discovery. *Sci Am*; 270: 82-87

Edeoga, H. O, Okwu, D.E and Mbaebie, B.O. (2005). Phytochemical constituents of some Nigerian medicinal plants. *Afr. J. Biotechnol*., 4: 685-688.

Fransworth NR, Morris RW (1976). Higher plants: The sleeping Giant of Drug Development. Am. *J. Pharm*., 148:46-52.

Harborne, J. B, 1973. Phytochemical Methods: A Guide to Modern Techniques of Plant Analysis Chapman A & Hall. London; 1973:279.

Li, Q., Zhu, L. F., But, P. P. H., Kong, Y. C., Chang, H. T. and Waterman, P.G., (1988). Monoterpene and Sesquiterpene rich oils from the leaves of *Murraya* Species: Chemotoxonomic Significance. Biochemical Systematics and Ecology 16: 491-494

Tawaha K, Alali FQM, Gharaibeh MM, El-Elimat T (2007). Antioxidant activity and total phenolic content of selected Jordanian plant species. Food Chem., 104: 1372-1378.

Thappa RK, Agrawal SG, Kanya LD, Gupta KV, Goswami KN (1996). Two Pyrroloquinazolines from A. vasica. Phytochem., 24: 1485-1488.

Trease, G.E. and W.C. Evans, 1989. Pharmacognosy.2nd Edn, Braille Tiridel and Macmillan publishers.

Socio-Economic Analysis of Forest Plant Utilized for Pile (Haemorrhoids) Treatment in Osun State, Nigeria

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ABSTRACT

The study analysed the socio-economics of forest plants utilized for pile (Haemorrhoids) treatment in Osun State, Nigeria. Multi-stage sampling technique was adopted in this study with the use of structured questionnaires that were administered to one hundred and fifty herb sellers. Descriptive statistics was used to analyse the socio-economic characteristics of the respondents, various types of plants that were used for the treatment of pile and problems encountered in the course of getting the plants. Economic valuation was determined through respondents' willingness to pay value (contingent valuation method). The results showed that majority of the respondents were literate (86%), females (80.67%), married (50%), and 56% respondents were Muslims. The study documented forty plants that belong to 29 families that were used for the treatment of piles by the respondents. Highest estimated economic value of ₦120.00 was recorded for Aframomum melegueta K. Schum. (Atare).This was followed by ₦100.00 recorded for Khaya grandifoliola (C.DC) (Oganwo) and Terminalia avicennioides Guill & Perr (Idin), respectively. The result also showed that (30%) of the respondents faced problem of distant location where forest plant species are sourced for onward conveyance to town. It is recommended that domestication of some of the plants be encouraged in order to prevent the extinction of the plants.

Keywords: Economic valuation, piles, herbal plants, location

INTRODUCTION

The use of plants and animals as source of medicine and food is as old as humanity. The therapeutic hints from remote mists of time hold key of the treasures of medical knowledge. Kafaru, (1994) reported that the use of plant for medicine dates back to the time of early man, who had crudest tools as he implements and used stones to start his fire. Studies had shown that Nigeria and in fact, the tropical world is endowed with abundant forest land rich in valuable plants and raw materials (Soladoye *et al.*, 1993). Cox and Balick, (2008) reported that when modern health care fails, the patient frequently turns to use of indigenous healthcare. Hence Nigerians that had once rejected the efficacy of the traditional medicine, now shift back again (Adodo, 2004). Ugbogu and Odewo (2004) identified some plants that cured about 17 ailments among which are malaria, cough, pile (haemorrhoids), anaemia, and skin diseases. Gbile, (1990) indicated some plants such as *Mangifera indica* Linn, *Newbouldia laevis* (P Beas) Seem. ex Bureau, *Allophylus africanus* P. Beav, *Anchomanes difformis* Keay, *Waltheria indica* Linn, and *Ocimum gratissimum* Linn., among others to cure ailments like malaria, diabetes, convulsion, stomach upset, glandular disorder and fontanel in infants. However, medicinal plants with their great potential have even solved a lot of problems. One of such problems is pile. Piles (haemorrhoids) are varicosities of the veins of the haemorrhoidal plexus, often complicated by inflammation, thrombosis and bleeding (Bharat, 2011). It is also a vascular cushion, consisting of thick sub mucosa containing both venous and arterial blood vessels. The word hemorrhoid is derived from the Greek "haema" meaning blood and "rhoos" meaning flowing. The word pile is derived from Latin meaning a ball or a mass (Sofowora, 1993). This paper therefore analysed the socio-economics of forest plant utilized for pile (Haemorrhoids) treatment in Osun State, Nigeria and determines the economic valuation of these forest plant species as well as identified the problems encountered in the course of getting the plant in the study area.

METHODOLOGY

The Study Area

The study area Iwo Local Government area of Osun State, had its headquarters in Iwo with latitudes $7^0$38N $4^0$11E and longitudes 7.633^0N 4.183^0E. It has an area of 245km^2 and the population of 191,348 (FOS, 2007). It has boundaries with Ola-oluwa Local Government Area in the north-east, Ayedire Local Government Area in the south and Lagelu Local Government Area of Oyo state in the west. The primary economic activities of the people are agriculture with the primary crops being cocoa, yam, corn, cassava and palm oil and also textiles.

Sampling Techniques, Sample Size and Methods of Data Collection

Multi-stage sampling procedure was used for study area. In the first stage, Osun State has three senatorial districts and Osun West Senatorial District was randomly selected. In the 2nd stage, out of the ten Local Government area in the senatorial district, Iwo Local Government Area were purposively chosen as the most populated Local Government area in the senatorial district as well as in the State (FOS, 2007). In the 3rd stage, Iwo Local Government Area has prominent towns and markets, out of which five major markets namely: Fesu, Papa, Ogburo, Agberire and Elemon adana where herbal sellers exist were purposively visited. In each market, thirty respondents were interviewed to make a total sampling size of 150 respondents in the study area. Data were collected through the use of structured questionnaire administered to purposively selected respondents in the stratum. Each questionnaire was divided into two major parts. Part one dealt with socio-economic characteristics of the respondents such as age, sex, marital status, educational attainment, etc., while part two contained questions on the uses of the forest plants and market price.

Data Analysis

Data generated were analysed using descriptive statistics. Economic valuation method as adopted by Adekunle (2005) was equally adopted to elicit Willingness to Pay (WTP) values for forest plants utilized for pile (Haemorrhoids) treatment in study area.

$$WTP = \frac{\sum fx}{n}$$ Where: WTP= mean willingness to pay value, Σ= Summation sign, f = frequencies of mention of plant species, x = Species value in Naira (₦) and n = Number of respondents.

RESULT AND DISCUSSION

Socio-Economic Characteristics of Respondents in the Study Area

Table 1 showed the socio-economic characteristics of respondents in the study area. Majority (80.67%) of the respondents were females. This implies that females were more involved in the sales of herbal product than their male counterparts. This enabled them to contribute part of income generated in their families for house-keeping. The distribution of age showed that 29.33, 22.67, 22.0 and 20.67 per cent of the respondents were within the range of 41-50, 31-40, 51- 60 and 21-30 years of age, respectively. This indicated that respondents were within the active age group. Fifty per cent of the respondents were married. The distribution by religion showed that majority were Muslims (56%) while Christians were 30% and only 14.0% of the respondents were Traditionalists. Household size of 1-5 (57.33%) dominated the study area. Educationally, 37.33, 34.0 and 14.67 per cent of the respondents had formal education (secondary, primary and tertiary education, respectively) while 14 per cent had no formal education. The implication was that majority of the respondents were literate which would have positive consequences on the capacity to exploit latent opportunities of any document kept on the uses of the forest plants. Consequently, 72.67% of the respondents were introduced into herbal business through inheritance. The implication was that knowledge about the plant uses was transferred especially from old people to younger generation; otherwise, once these people die the information about the use is lost. Majority (69.33%) of the respondents fund the business through their personal savings. Out of the total respondents, 42.67 per cent had between 11-15 years of experience in the business while 50.67 per cent earned between ₦40,001.00-50,000.00 monthly. The distribution of the respondents based on problem encountered showed that (30%) of the respondents reported that distance of the forest plant species to town was one of the major problems usually encountered. Twenty per cent of the respondent had problem of location of the forest plants as a result of swampy area before getting across to where the plants are sourced while 20% had no problem of getting the forest plant species. However, 10% of the respondents had problem of stains and piercing of the plant stalk while 6.7 and 3.3 per cent, respectively of the respondents had problems of tallness and odour of the plant.

Different Types of Forest Plants Used for Pile Treatment and Economic Valuation of the Forest Plant Species in the Study Area

Table 2 showed that 40 plants species were used for the treatment of pile in the study area. This study was in line with the study of Soladoye *et al.*, (2010), Borokini *et al.*, (2013), and Thiyam *et al.*, (2014) where plant species utilized for the treatment of pile in Oyo, Ogun and Lagos States, Southwest, Nigeria as well as Andro village in Imphal East District, Manipur (India) were reported. Also, it is an update of Odewo *et al*., (2014), that reported 20 medicinal plants for curing pile in Ago-Owu Forest Reserve, Osun State. Various plant species identified in the various prominent town and markets sampled indicated how these plants are available in the area covered. Pei (2001) reported that traditional medical knowledge of medicinal plants and their uses by indigenes are not only useful for conservation of cultural and traditional beliefs and biodiversity but also for the community healthcare and drug development in the present and future.

Economic valuation of the forest plant species used for pile treatment in the study area was derived from the respondents' willingness to pay. The result showed that ₦300.00 was the highest amount recorded for *Terminalia avicennioides* (Idin). This was followed by ₦270.00 that was recorded for *Curculigo pilosaq* (Epakun) while ₦250.00 was recorded for *Ananas comosus* (Ope oyinbo*), Azadirachtain indica (*Dongo-yaro*), Gongronema latifolium* (Madunmaro), and *Khaya grandifoliola* (Oganwo), respectively. The lowest amount of ₦120.00 was recorded for *Annaccadium occidentale* (Kaju), *Ocimum gratissimum* (Efinrin), *Picralima nitida* (Abere) and *Vernonia amygdalina* (Ewuro). However, these amounts translated to highest estimated economic value of ₦120.00 recorded for *Aframomum melegueta* (Atare), followed by ₦100.00 that was recorded for *Khaya grandifoliola* (Oganwo) and *Terminalia avicennioides* (Idin), respectively. The frequency of patronage of the plant species determined the values of the plant species. The economic values obtained in this study for forest plant species used for pile in the study area was an indication of the value society placed on such plant species. Adekunle (2005) reported that significant positive economic values were obtained; they did represent genuine positive values of the species identified.

Figure 1 showed that method of preparation of the forest plant species in the study area revealed (60%) by concoction while 40% of the forest plant species by decoction. Forty plants species used for the treatment of pile in the study area belong to 30 families (Table 3). Out of these 30 families, 80% of the family were each represented by one species while 10% of the family were represented by two and three species, respectively. The trend was that a broad diversity of families and species were used by the people. Categorizations of the plant species (Table 3) showed that 15% of the forest plant species had fruits and bark parts; mostly used in the preparation methods. Also, 12.5% of forest plant species had their leaves; seeds and roots parts jointly used. These parts were also used alone. Plant form categorizations of the species showed that Trees had 37.50% species followed by Herbs with 27.5% species, Shrub with 15% species, Climbers with 12.5% species, Shrub/Tree with 5%, and Climbers/Shrub were 2.5%, respectively.

CONCLUSION AND RECOMMENDATION

Based on the finding of this study, majority of the herb sellers were females and they were married. This study documented forty plant species used in the treatment of piles by the respondents with economic values of the plants. The larger families had one species of plant. It was observed that some highly prioritized plants had low economic values and vice versa. This further strengthened the relationship between indigenous knowledge, ethno-medicinal practices, drug discovery and pharmacology which in turn enhanced the socio-economic lives of the people of Osun State. Scientific studies on these plants too would yield interesting results and help us in understanding the pharmacological actions of the active compounds found in these plants as suggested by Ramana, (2008). Further investigation will throw more light about the vast wealth of ethno-botanical information possessed by the State. It is recommended that domestication of some of the plants be encouraged in order to prevent the extinction of the valuable plants as they are fast disappearing from the African flora especially Nigerian's endemic species due largely to deforestation of the conserved forest.

REFERENCES

Adodo, A. (2004): Nature power, a Christian approach to herbal medicine (3rd Ed.) Don Bosco Printing Press, 288pp

Adekunle, M.F (2005): Economic valuation of forest plants Used in traditional treatment of Guinea Worm Infection in Ogun state. Unpublished PhD. Thesis submitted to the department of Forestry and Wildlife Management, University of Agriculture, Abeokuta, Ogun state, Nigeria. 182pp.

Borokini, T.I, Ighere, D.A, Clement, M., Ajiboye, T.O and Alowonle, A. A (2013): Ethno-biological Survey of Traditional Medicine Practice for The Treatment of Piles and Diabetes Mellitus in Oyo State, Nigeria. Journal of Medicinal Plants Studies Vol. 1 (5) 30pp. **www.plantsjournal.com**

Bharat, G. (2011): Biotechnology laboratory IPCOWALA Santram institute of Biotechnology and emerging sciences, Dharmaj, 388438, Gujarat India. 149p.

Cox, P.A. and Balick, M. (2008): The Ethno-botanical approach to drug discovery. In: The Integration of Caribbean, A study in the U.S. Virgin Islands, pp70 – 82.

Federal Office of Statistic, (2007): Federal Republic of Nigeria official Gazette No 24 15th May 2007 Vol.94, Printed and published by the Federal government printer Lagos, Nigeria. FGP71/5/2007/2500 (OL24) Pp192-193

Gbile, Z.O. (1990): Plants in the traditional medicine in West Africa. In: Modern studies in African botany. (edsGoldblast, p.p

and Lowey, p.p), missour botanic Gardern, Missouri,U.S.A. 343-349pp.
Kafaru, E. (1994): Immense help from workshop. Elikaf services health Ltd, Lagos, 54-58pp.
Odewo, S.A, Fapojuwomi, O.A, Ajani, B.A, Adepoju, O.D, Sikiru, G.K (2014): Ethnobotanical Survey of Some Medicinal Plants for Curing Pile (Hemorrhoids) in Ago-Owu Forest Reserve,OsunState Nigeria *Journal of Natural Sciences Research* Vol.4(20) 9pp.www.iiste.org.
Pei, S. J. (2001): *Pharmaceutical Biology* 2001, 39:74-79.
Ramana, M. V**.** (2008): *Ethno-botanical Leaflets* 12: 391-400. 2008.
Sofowora, A. (1993): Medicinal plants and traditional medicine in Africa 2 nd edition, spectrum Boo Ltd. 387- 390pp.
Soladoye, M, O., Yakubu, F. A., Kola-Oladiji, K., Alabi, D. A. & Agbomeji, Y. O. (1993): The Collection, Conservation and Cultivation of Local Medicinal Plants for Natural Medicine Production. Paper presented at the Seminar/Workshop and Exhibition of Natural Medicine Products. Organized by Nigeria Traditional Medical Association, Ijebu-North in Collaboration with Faculty of Science, Olabisi Onabanjo University Ago-Iwoye, held 19-23 September, 1993.
Soladoye, M.O, Adetayo, M. O., Chukwuma, E. C, and Adetunji, A. N (2010): Ethnobotanical Survey of Plants Used in the Treatment of Haemorrhoids in South-Western, Nigeria. Scholars Research Library Annals of Biological Research, Vol. 1 (4): 1-15.
Thiyam T.S., Hanjabam, M. S., Anoubam, R. D, Hanjabam, R. S (2014): Plants used in the treatment of piles by the scheduled Caste community of Andro village in Imphal East District,Manipur (India) *Journal of Plant Sciences* 2(3): 113-119. Published online July 10, 2014 (**http://www.sciencepublishinggroup.com/j/jps)**
Ugbogu, O.A and Odewo, T.K. (2004): Some Medicinal Plants in the Traditional Medicare of Nigeria. *Journal of Forestry Research and Management*, Vol. (1&2).29pp.

Table 1: Distribution of Respondents by Socio-economics Characteristics in the Study Area

Socio-economics Variables N = 150	Frequency	Percentage
Sex		
Male	29	19.33
Female	121	80.67
Age (Years)		
≤ 20	8	5.33
21 – 30	31	20.67
31 – 40	34	22.67
41 – 50	44	29.33
51- 60	33	22.00
Mean	40	
Marital Status		
Married	75	50.00
Single	24	16.00
Widower	34	22.67
Divorce	17	11.33
Religion		
Muslim	84	56.00
Christian	45	30.00
Traditional	21	14.00
Household Size		
≤5	86	57.33
6 -10	47	31.33
≥11	17	11.33
Mean	5	

Source: Field Survey, 2015

Table 1 Cont'd.: Distribution of Respondents by Socio-economics Characteristics

Socio-economics Variables N = 150	Frequency	Percentage
Educational Status		
No formal Education	21	14.00
Primary	51	34.00
Secondary	56	37.33
Tertiary	22	14.67
Mode of Acquisition of Occupation		
Inheritance	109	72.67
Apprenticeship	41	27.33
Source of capital		
Personal savings	104	69.33
Bank Loan	28	18.67
Cooperative	18	12.00
Years of Experience		
≤ 6	28	18.67
6 – 10	41	27.33
11 – 15	64	42.67
16 – 20	13	8.67
≥ *21*	4	2.66
Mean	11	
Monthly Income (₦)		
≤ 30,000.00	8	5.33
30,001.00-40,000.00	36	24.00
40,001.00-50,000.00	76	50.67
50,001.00-60,000.00	23	15.33
≤ 60,001.0000.00	7	4.67
Mean (₦)	44,520.00	
Distribution of Respondents Based on Problem Encountered		
Distance to Town	45	30
Location of the plant (Swampy Area)	30	20
Plant Height (Tallness)	10	6.7
Piercing of the stalk	15	10
Stain from the plant	15	10
Odour from the plant	05	3.3
Nil	30	20

Source: Field Survey, 2015

Table 2: Different Types of Forest Plant Species utilized for Pile (Haemorrhoids) Treatment, Methods of Preparation and Estimated Economic Valuation of the Forest Plant Species in the Study Area

S/N	Forest Plant Species			Plant Parts Used	Mtd. of Prep.	PF	Freq.	Amount X (₦)	Economic Valuation (₦)
	Scientific Name	Local Name	Family Name						
1	*Abrus precatorius* Linn.	Oju ologbo	Legummoseae	Leaf	C	Cl	35	150.00	35.00
2	*Acacia nilotical* (Linn.) wild ex. Del.	Booni	Mimosaceae	Seed	C	Tr	35	150.00	35.00
3	*Aframomum melegueta* K.Schum.	Atare	Zingiberaceae	Fruit	C	H	89	200.00	120.00
4	*Allium ascalonicum* L. Backer	Alubosa Elewe	Liliaceae	Bulb	C	H	86	150.00	90.00
5	*Allium satirum* Linn.	Ayu	Liliaceae	Bulb	D	H	61	170.00	70.00
6	*Amaranthus spinosus* Linn.	Tete abalaye	Amaranthacee	Whole plant	D	H	4	150.00	84.00
7	*Ananas comosus* (Linn.) Merrill.	Ope oyinbo	Bromeliaceae	Fruit	C	H	47	250.00	80.00
8	*Annaccadium occidentale* Linn	Kaju	Anacardiaceae	Bark	C	Tr	69	120.00	55.00
9	*Anogeissius leiocarpus* (DC.) Guill P	Ayin	Combretaceae	Bark	D	Tr	56	200.00	75.00
10	*Anthoueista djalonensis* A.Chev	Sapo	Loranthaceae	Bark	C	Tr	43	200.00	60.00
11	*Aristolochia ringens* Vahi	Akogun	Aristolochiaceae	Bark	D	Cl	34	150.00	35.00
12	*Azadirachtain* indica	Dongo-yaro	Meliaceae	Leaf, Bark	D	Tr	45	250.00	75.00
13	*Capsicum annuum* Linn.	Ata ijosi	Solanaceae	Fruit	C	H	79	150.00	80.00
14	*Citrullus lanatus* (Thunb.)	Bara	Cucurbitaceae	Fruit	C	H	25	200.00	30.00
15	*Colocynthis citrullus*(L.) Schrad	Egusi baara	Cucurbitaceae	Bulb	D	H	45	200.00	60.00
16	*Cucurbita* maxima Duchesne	Elegede	Cucurbitaceae	Leaf, Root	C	H	42	200.00	60.00
17	*Curculigo pilosaq* (Schum & Thonn)	Epakun	Hypoxidaceae	Rhizorne	C	H	34	270.00	60.00
18	*Eugenia aromatica* (L.) Baill	Kanafuru	Myrtaceae	Bark, Fruit	D	Tr	45	150.00	50.00
19	*Gongronema latifolium* Benth	Madunmaro	Asclepiadaceae	Root	C	Cl	35	250.00	60.00
20	*Hunteria-unbellata* (k/schun) ler.F.	Erin	Apocynaceae	Stem, Bark	D	H	28	160.00	30.00
21	*Jatropha curcas* L.	Lapalapa Funfun	Euphorbiaceae	Leaf, Seed	D	S	84	150.00	84.00
22	*Jatropha gossypifolia* Linn	Lapalapa Pupa	Euphorbiaceae	Leaf	D	S	79	160.00	84.00
23	*Khaya grandifoliola* (C.DC)	Oganwo	Malvaceae	Bark	C	Tr	58	250.00	100.00
24	*Kigelia africana* (Lam.)Benth	Pandoro	Bignoniaceae	Seed, Root	D	Tr	41	300.00	80.00
25	*Momordica charantia* Linn.	Ejinrin-were	Cucurbitaceae	Leaf	C	Cl	91	150.00	90.00
26	*Mondora myristica* (Geatn Dunnal)	Sasangbaku	Annonceae	Fruit	C	Tr	36	200.00	50.00
27	*Morinda lucida* Benth.	Oruwo	Rubiaceae	Leaf, Root	C	Tr	82	150.00	80.00

Source: Field Survey, 2015. MTD of Prep.: Method of Preparation, C: Concoction, D: Decoction, PF: Plant Form, CL: Climbers, Tr: Tree, H: Herbs, S: Shrub, S: Shrub, S/T: Shrub/Tree, CL/S: Climbers/Shrub. Values are rounded up to the nearest naira.

Table 2 Cont'd. : Different Types of Forest Plant Species utilized for Pile (Haemorrhoids) Treatment, Methods of Preparation and Estimated Economic Valuation of the Forest Plant Species in the Study Area

S/N	Forest Plant Species			Plant Parts Used	Mtd. of Prep.	PF	Freq.	Amount X (₦)	Economic Valuation (₦)
	Scientific Name	Local Name	Family Name						
28	*Musa paradisiaca*	Ogede agbagba	Musaceae	Leaf	D	Tr	49	200.00	65.00
29	*Ocimum. gratissimum* L.	Efinrin	Lamiaceae	Leaf, Scent	C	S	95	120.00	80.00
30	Picralima nitida (Stapf.)Th. & H.Dur.	Abere	Apocynaceae	Seed, Root, Bark	C	Tr	39	120.00	30.00
31	*Piper guineense* Schum & Thonn	Iyere	Piperaceae	Fruit, Bark	C	Cl	56	150.00	60.00
32	*Psidium guajava.*Linn	Grofa	Myrtaceae	Root	C	Tr	54	150.00	50.00
33	Pteleopsis Engl. & Diels suberosa	Okuku	Combretaceae	Bark	C	S/T	42	150.00	40.00
34	*Rauvofia Vomitoria* Afzel Strip Med.	Orira	Apocynaceae	Stem, Bark	C	Cl/S	25	200.00	30.00
35	*Senna alata* L. Roxburgh	Asunwon oyinbo	Caesalpiniaceae	Leaf, Flower	D	S	71	170.00	80.00
36	*Senna fistula* L.	Aidan tooro	Caesalpiniacea	Root, Bark	C	S	62	180.00	75.00
37	*Terminalia avicennioides* Guill. & Perr	Idin	Combretaceae	Twigs/Stem	D	Tr	48	300.00	100.00
38	*Thaumatococcus danielli* (Benn.)	Ewe-iran	Marantaceae	Root, Seed	D	Tr	48	140.00	50.00
39	*Vernonia amygdalina* Del.	Ewuro	Asteraceae	Leaf	C	S/T	98	120.00	80.00
40	*Viscum album* L.	Afomo	Loranthaceae	Whole plant	D	S	74	150.00	70.00

Source: Field Survey, 2015. MTD of Prep.: Method of Preparation, C: Concoction, D: Decoction, PF: Plant Form, CL: Climbers, Tr: Tree, H: Herbs, S: Shrub, S: Shrub, S/T: Shrub/Tree, CL/S: Climbers/Shrub. Values are rounded up to the nearest naira.

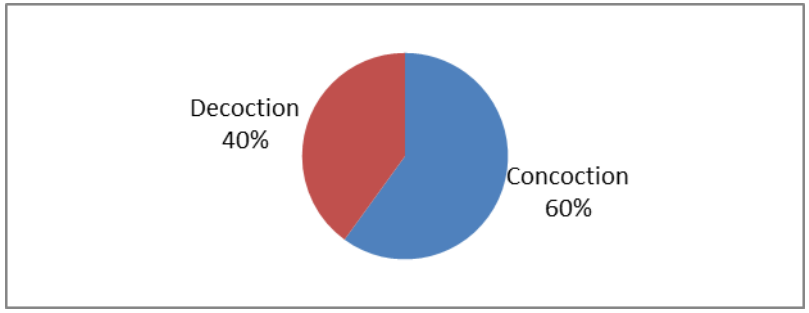


Figure 1: Categorization of Different Types of Forest Plant Species Utilized for Pile Treatment by Methods of Preparation of the Plant in the Study Area

Table 2: Categorization of Different Types of Forest Plant Species Utilized for Pile Treatment by Family, Plant Parts Used and Plant Form in the Study Area

S/N	Family Name	No	%	Plant Species Parts Used	No	%
1.	*Amaranthaceae*	1	2.5	Bark and Fruit	2	5.0
2.	*Anacardiaceae*	1	2.5	Barks	6	15.0
3.	*Annonceae*	1	2.5	Bulb	3	7.5
4.	*Anstolochiaceae*	1	2.5	Fruits	6	15.0
5.	*Apocynaceae*	3	7.5	Leaf	5	12.5
6.	*Asclepiadaceae*	1	2.5	Leaf and Bark	1	2.5
7.	*Asteraceae*	1	2.5	Leaf and Flower	1	2.5
8.	*Bignoniaceae*	1	2.5	Leaf and Stem	1	2.5
9.	*Bromeliaceae*	1	2.5	Leaf, Seed, Root	5	12.5
10.	*Caesalpiniaceae*	2	5.0	Rhizome	1	2.5
11.	*Combretaceae*	3	7.5	Root and Bark	1	2.5
12.	*Euphorbiaceae*	2	5.0	Roots	1	2.5
13.	*Hypoxidaceae*	1	2.5	Seed	1	2.5
14.	*Lamiaceae*	1	2.5	Seed, Root and Bark	1	2.5
15.	*Legummosa: papillonoideae*	1	2.5	Stem, Bark	2	5.0
16.	*Lilaceae*	2	5	Twig and Stem	1	2.5
17.	*Loranthaceae*	1	2.5	Whole plants	2	5.0
18.	*Loranthaceae*	1	2.5	**Plant Form**		
19.	*Mumosaceae*	1	2.5	Climbers	5	12.5
24.	*Marantaceae*	1	2.5	Climbers/Shrubs	1	2.5
21.	*Meliaceae*	1	2.5	Herbs	11	27.5
22.	*Moringaceae*	1	2.5	Shrubs	6	15.0
23.	*Malvaceae*	1	2.5	Shrubs/Tree	2	5.0
20.	*Musaceae*	1	2.5	Tree	15	37.5
25.	*Myrtaceae*	1	2.5			
26.	*Piperaceae*	1	2.5			
27.	*Rubiaceae*	1	2.5			
28.	*Solanaceae*	1	2.5			
29.	*Zingiberaceae*	1	2.5			

Source: Field Survey, 2015.

Indigenous Uses of Forest Plant Leaves for Traditional Healthcare in Ogun State, Nigeria

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ABSTRACT

There is need to gather information on the medicinal value of forest plant leaves. This information is useful in documenting different plants utilized for traditional health care. Forest plant species used for traditional healthcare in Ogun State, Nigeria, were investigated with emphasis on those used by the respondents to treat 23 different types of ailment. Multi-stage sampling technique was adopted in this study. A total of one hundred and seventy-four respondents were sampled according to population distribution in each area. Structured questionnaires were administered through interview schedules on some randomly selected household users. Descriptive tools were used to summarize the result of the study. The results showed that 47 plant species from 27 families were used for these ailments. Out of the 47 forest plant species, 29.78% of the plants were used mostly for treating pains of different parts of the body, followed by cough and hypertension where 14.89% and 12.77% of the plants were used, respectively. These plants consisted of herbs (34.04%), trees (23.4%), climbers (14.89%) and shrubs (12.77%). Also, of these 27 families, 40.41% of the plants had only one species while 21.28% had only two species implying that if the species become extinct, the family could be wiped out. As a result of these valuable plant species, it is essential and therefore, recommended that domestication be carried out in order to prevent and avert the extinction of these plants along with other lost African flora especially in Nigeria due largely to deforestation.

Keywords: Traditional healthcare, indigenous uses, forest plant leaves

INTRODUCTION

Forest plant leaves are found within diverse ecological zones of Nigeria. Depending on the species involved, a particular product may be restricted to or span through more than one ecological zone. For instance, leafy vegetables are obtained from various species in the different ecological zones. Leaves are put into different uses, which include food, medicines, roofing, household utensils and cultural values (Adekunle and Oluwalana, 2002). World Health Organization (WHO, 2003), approximately estimate that eighty percent of the people in developing countries depend on forest plants through traditional medicine for primary health care needs. De Silva (1997) noted that modern pharmacopoeia still contain at least 25 per cent drugs derived from plants and many others which are synthetic analogues built on prototype compounds isolated from plants. Unfortunately, however, indigenous people have been more than decimated. This is an irreversible loss of cultural diversity and ultimately, loss of indigenous knowledge with a myriad of biological consequences. In addition, natural resources are vanishing before people become aware of their existence (Balick and Cox, 1997). The historical dependency of human beings on forest is still intact either directly or indirectly for fulfilling their various needs, such as food, fodder, fiber, medicine and cultural epistemic. The age-old traditional interaction of people living in surrounding forest, natural resources, ecosystem and environment have developed some specific knowledge on the use of forest and forest resources (Kala, 2005). The selection of plant species for use depends on the knowledge and experiences.However, the dependency or exploration of forest resources is determined by the richness of the produces or the availability of the resources (Kala, 2009). The creativity, evolution and accumulation of knowledge depend on the locality, availability and opportunity to access the resources.

This study centered on documentation of indigenous utilization of forest plant leaves species used for traditional healthcare in Ogun State, Nigeria with a view to providing information on the indigenous knowledge of forest plants leaves in healthcare delivery systems.

METHODOLOGY

The Study Area

Ogun State, created in February, 1976 from the Old Western State of Nigeria, is one of the 36 states in Nigeria. It covers an area of 16,762km^2 (FOS, 2007). This includes a total area of 2,371.48km^2 of forest reserve (Ogun State Forestry Department, 1996). The state lies between Latitudes 6° and 8°N and Longitude 2°31 and 5°E. It is situated in the moist tropical rain forest zone. The State usually experiences two seasons: the rainy season between March and November, and the dry season, November to March. Ogun State with a population of 3,728,098 million people (FOS, 2007) has 20 local government areas. The study area was divided into three divisions: Egba, Yewa and Ijebu/Remo as sub-ethnic divisions. The areas were based on ecological and climatic factors having political characteristics that fall along sub-ethnic divisions in the State. Egba and Yewa areas have forest and derived savanna vegetation types while Ijebu/Remo is in the rainforest region.

Sampling Techniques

Multistage sampling procedure was adopted in selecting the sample population from which data were collected for this study. The State was first divided into three divisions representing the first stage of sampling which produced a sample of primary selection unit. Each primary selection unit denotes a stratum. In the second stage of sampling, from each of these divisions, three (3) local government areas were selected based on pre-tested survey information. In the third stage, the number of respondents was determined with Probability Proportional to Size (PPS) based on population distribution in the strata. One hundred and seventy four respondents that relied on forest plant leaves as household users and traditional users were also randomly selected based on PPS determined number. Ogun State with a population of 3,728,098 million people (FOS, 2007) has 20 local government areas. The study covers 9 local government areas (45%) from where respondents were selected. The populations of the strata were as follows: Egba–1,369,900, Ijebu–1,248,314 and Yewa–1,109,884, with a pre-determined sample size of 174 respondents, the sampling pattern was as follows: Egba – 64 Respondents (3 local government areas), Ijebu – 58 Respondents (3 local government areas), Yewa – 52 Respondents (3 local government areas).

Data Analysis

Data collected were analyzed and using descriptive statistics.

RESULTS AND DISCUSSION

The summary of the plant species and frequency of mentioning of the plants are presented in Tables 1 while categorization of different types of forest plant leaves utilized for traditional healthcare treatment in the study area are also presented in Table 2. In Table 1, plants with the highest frequency of mentioning were *Citrus aurantifolia"*Ewé Osàn wéwé"; 156 respondents, this was followed by *Chromolaena odorata* "Ewé Akíntólá-ta-kú"; 152 respondents and *Vernonia amygdalina* "Ewé Ewúro"; 145 respondents while the least mentioned plants were *Dalbergia lacteal* "Ewé Òjìjí" and *Icacina trichanta* "Ewé Gbégbé"; 21 respondents, respectively. This was followed by *Croton lobatus* "Ewé Èérú"; 24 respondents and *Heliotropium indicum* "Ewé Agogo igún"; 28 respondents. The majority of the uses of the forest plant leaves for various traditional healthcare treatments were not surprising because in man's quest for subsistence, some of his foremost priorities have been food and good health. As herbs have usually served as a repository of healing materials and have been acknowledged to be generally safe without or with minimum side effects (Gbile and Adesina, 1986). The plant leaves are important ingredients in traditional treatment of various diseases as it featured as a component in many herbal preparations which were in agreement with Adekunle (2008) and Ayodele (2005). The results reflected that the use were broadly known by the respondents though knowledge and the uses were diverse and varied among individuals, families and communities. There are, however, key individuals who are custodians of very "sensitive" knowledge. These people are those who invariably act as "healers" or "consultants" in their communities. The result also showed that forty-seven (47) of the forest plants species utilized for different traditional ailments treatment belonged to 27 families (Table 2). This is in line with the study of Adekunle and Oluwalana (2004) that reported 22 forest plants species similarly used for traditional healthcare in Ondo State that belonged to 20 families. While Erinoso and Aworinde, (2012) reported 58 forest plant species of 34 families used for eleven or more ailments in Abeokuta metropolis. Of these 27 families in this survey, 40.41 % were each represented by one species while 21.28 % were represented by two species. Other families were represented by three, five and ten species which were 6.38%, 10.64% and 21.28%, respectively. The trend was that a broad diversity of families and species were used by the people. Plant form categorizations of the species were also shown in Table 2. Herbs had 34.04% species, followed by Trees with 23.4% species, Climbers with 14.89% species, Shrubs with 12.77% species, Shrub/Tree with 8.51%, Bulbous plant, Liane, and Twines were 2.13% , respectively. These plants can be used for the treatment of 23 ailments. Out of the 47 forest plant species, 29.78% of the plants were used mostly for pains of different parts of the body (chest, stomach, whole body, high body temperature, headache, waist, and backache). This is followed by cough, hypertension, asthma, and wound where 14.89%, 12.77%, 10.64%, and 8.51% of the plants were used for the traditional treatment of

the different ailments, respectively. This study is an update of the uses of forest plants leaves in the State. It has shown that indigenous medicinal plants exist, and the uses depend on the knowledge available to the respondents. The plants can be exploited for the development of new modern drugs for the treatment different ailments. These plants are similarly reported by Odugbemi and Akinsulire (2008). The method of preparation of the plant leaves were mostly by decoction (55.32%) while 10.64% of the plants were prepared as concoctions. Some of the plants can be prepared as concoction as well as decoction (12.77%) while some can be prepared as cream (2.13%) and some plant leaves can be squeezed to get the juice extracts from the leaves to be applied topically or for oral administration. The leaves of these plants were used mostly in the fresh form (93.62%) and also as both fresh and dried forms (6.38%). The forest plant leaves were mostly of dry land habitats (78.72%), 91.49% of the plants are usually scarce during the dry season, 95.75% are in abundant during the rainy season. This is in line with *a priori* expectation that plant should be in abundant during the rainy season due to rainfall impact on the vegetation. The categorization further revealed that 97.87% of the plants are common; all the plants are not extinct but 2.13% of the plants are rarely found around. This implies that the plants are readily available for use. Majority (95.75%) of the plants are sourced from the cultivated garden around while 19.15% were sourced from the wild. Preserving these plants, 97.87 % of the plants were usually sun dry while 2.13 % of the plants were not. Similarly, 72.34 % of the plants were also air dried while 27.66% of the plants were not (Table 2). Some management implications can be deduced from this study, for instance deforestation has been a bane to sustainable utilization of forest resources especially in the tropical countries like Nigeria. For instance majority of the plants are not from the wild, if the area is cleared for other purposes, these plants might not be available for use again (FAO, 2006).

CONCLUSION AND RECOMMENDATIONS

The findings of this study revealed that people of the State make use of the plant species from their environment and are equipped with indigenous knowledge of the plant uses for traditional medicines and survival. However, some of the uses reported have not been scientifically proved. There is therefore, the need to prove this in forestry and pharmaceutical research. it is recommended that domestication of some of the plants should be done in order to prevent the extinction of the plants as they are fast disappearing in the African flora especially Nigerian due largely to deforestation of the conserved forest. Also, further ethno-botanical research and scientific investigation are required to help preserve indigenous knowledge.

REFERENCES

Adekunle, M. F (2008). Indigenous Uses of Plants Leaves to Treat Malaria Fever at Omo Forest Reserve (OFR), Ogun State, Nigeria Ethiopia J. Environ. Stud. Man., 1(1): 31-35

Adekunle, M. F. and S.A. Oluwalala (2002): Utilization of forest plant leaves in Omo Forest Reserve, Ogun State, Nigeria. *The Ogun Journal of Agriculture Science Vol.* II: 238-253p

Adekunle, M. F. and S. A. Oluwalala (2004): Forest plants in Traditional Healthcare in Owo Local Government Area Ondo State, Nigeria: implications for tertiary level curriculum and Non- -timber forest products. In: Rebuilding Africa's capacity for agricultural development: The role of tertiary education, Proceedings of a symposium on Tertiary Agricultural Education by ICRAF, (A. Temu, S. Chakeredza, D. Mogotsi, D. Munthall, & R. Mulinge (eds.) at African Network for Agroforestry Education (ANAFE), Nairobi, Kenya, Pp.227-232

Ayodele, A. E (2005); The Medicinally Important Leafy Vegetables of South-Western Nigeria (http//www.siu.edu/ebl/leaflets/ayodele/html)

Balick, M. and Cox, P .A (1997); Ethno botanical research and traditional health care in developing countries. In: *Medicinal plants for forest conservation and health care, Non - Wood Forest Products 11,* FAO Rome Pp 12 – 23.

De Silva, T. (1997): Industrial utilization of medicinal plants in developing countries, In: Medicinal plants for forest conservation and health care. *Non-Wood Forest Products NWTP* 11, FAO, Note 6 Rome. Pp. 34-44.

Erinoso S. M and Aworinde, D. O (2012); Ethnobotanical survey of some medicinal plants used in traditional health care in Abeokuta areas of Ogun State, Nigeria African Journal of Pharmacy and Pharmacology Vol. 6(18), pp. 1352-1362, Available online at **http://www.academicjournals.org/AJPP** DOI: 10.5897/AJPP12.127 ISSN 1996-0816 ©2012 Academic Journals

Food and Agriculture Organization (2006): Food and Agriculture Organization (FAO) *Unasylva* 224, Vol. 57, 2006 Pp. 20

Federal Office of Statistic, (2007): Federal Republic of Nigeria official Gazette No 24 15th May 2007 Vol.94, Printed and published by the Federal government printer Lagos, Nigeria.FGP71/5/2007/2500 (OL24) Pp192-193

Gbile, Z.O and Adesina, S. K (1986); Nigerian Flora and Its Pharmaceutical Potentials. J. Ethnopharmacol., 19: 1-16.

Odugbemi, T. and Akinsulire, O., (2008): In outlines and pictures of Medicinal Plants from Nigeria Chapter Nine – Medicinal Plants by Species. Edited by Odugbemi T. Printed and bound in Nigeria by university of Lagos Press, Akoka, Yaba-Lagos State. ISBN: 978-978-48712-7-3 Pp 73-116

Ogun State Forestry Department (1996): Memo on the State of Forestry in Ogun State, Submitted by the Advisory Committee on Forestry, Agriculture, Industry, and Revenue Generation in Ogun State

Kala, C.P. (2005): Ethno-medicinal Botany of the Apatani in the Eastern Himalayan Region of India. *Journal of Ethno-biology and Ethno-medicine,* 1 (11):1-12

Kala, C.P. (2009): Aboriginal Uses and Management of Ethno-botanical Species in Deciduous Forest of Chhattisgarh State, India. *Journal of Ethno-biology and Ethno-medicine*, 5:1-12

World Health Organization WHO (2003): Guidelines on Good Agricultural and Collection Practices (GACP) for medicinal plants, p. 1.Geneva, *Fact Sheet Number 134*.

Table 1: Different Types of Forest Plant Leaves Utilized for Traditional Healthcare Treatment in the Study Area

S/N	Forest Plant Leaves Species			Plant Form	FU	Ailment Used for?	MTD of P	HBT	PH		Avbty			Srce		Psvtn		Freq.
	Local Name	Scientific Name	Family Name						Scarce	Abnt	Rare	Cmn	Ext	Wild	Ctvt	sun	AD	
1	Èwé Mesén-mesén / Ojúólogbò	*Abrus precatorius* Linn.	Leguminosae: Papiloinoideae	Climbers	F	For treatment of hypertension, Asthma, and Cough.	C, D	DL	D	R	N	Y	N	N	Y	Y	Y	50
2	Ewé bòmi	*Acacia macrostachya* DC.	Leguminosae: Mimosoideae	Tree	F	For Cough treatment	D	B	D	R	N	Y	N	N	Y	Y	N	70
3	Ewé Àpasá / Ímí èsè	*Ageratum conyzoides* Linn.	Asteraceae	Herb	F	For treatment of fresh wound and Sore.	C, Cr	M WL	D	R	N	Y	N	N	Y	Y	Y	90
4	Ewé Isaju	*Albizzia zygia* (DC.) J. F. Macbr.	Leguminosae: Mimosoideae	Tree	F	As cure for Ulcer.	D	M WL	D	R	N	Y	N	Y	Y	Y	Y	95
5	Ewé Àlùbósà – eléwé	*Allium ascalonicum* L.	Alliaceae	Herb	F	Used in treating hypertension.	D	WL	D	R	N	Y	N	N	Y	N	Y	120
6	Ewé Áyù	*Allium sativum* Linn.	Alliaceae	Herb	F	For treatment of Asthma, hypertension.	D	DL	D	R	N	Y	N	N	Y	Y	Y	133
7	Ewé bóńgà	*Ampelocissus leonensis* Linn.	Ampelidaceae	Climber	F	For treatment of syphilis.	D	DL	D	R	N	Y	N	Y	N	Y	Y	67
8	Ewé Múnútòrò	*Basella alba* Linn.	Basellaceae	Climber	F	For Prevention of stroke.	D	WL	D	R	N	Y	N	N	Y	Y	N	86
9	Ewé Èsó	*Bombax buonopozense* P. Beauv.	Bombacaceae	Tree	F	For chest pain treatment.	C, D	WL	D	R	N	Y	N	N	Y	Y	N	56
10	Ewé Àbámodá	*Bryophyllum pinnatum* (Lam.) Oken	Crassulaceae	Herb	F	For treatment of Ulcer, high body temperature. The leaves are grind and poured or mixed with shear butter or palm oil as cream for the body.	Cr , D	DL	D	R	N	Y	N	N	Y	Y	N	98

Source: Field Survey, 2012. FU: Form Use, F: Fresh, MTD of P: Method of Preparation, C: Concoction, D: Decoction, Cr: Cream , Abnt: Abundant, DL: Dry land, AD: Air Dry, Avbty: Availability B: Both Dry Land and Wet Land, Cmn: Common, Ctvt: Cultivated, D: Dry Season, Ext: Extinct, HBT: Habitat, MWL: Mostly Wet Land, N: No, PH: Period of Harvest, Psvtn: Preservation, R: Rainy season, Y: Yes, WL: Wet land

Table 1 Cont'd.: Different Types of Forest Plant Leaves Utilized for Traditional Healthcare Treatment in the Study Area

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	Local Name	Scientific Name	Family Name						Scarce	Abnt	Rare	Cmn	Ext	Wild	Ctvt	sun	AD	
11	Ewé Bomu bómú	*Callotropis procera* (Ait.) Ait. f.	Asclepiadaceae	Shrub	F	For treatment of syphilis and cough.	C, D	B	D	R	N	Y	N	N	Y	Y	N	142
12	Ewé Ògbómonígèlè gélé	*Cassytha filiformis* Linn.	Lauraceae	Herb-Twinning (vine)	F	It is used for a child that is about to walk, to aid the child's walking ability during growth.	C	DL	D	R	Y	N	N	N	Y	Y	N	92
13	Ewé Atò	*Chasmanthera dependens* Hochst.	Menispermaceae	Liane	F	For bone treatment or bone fracture	Cr	DL	D	R	N	Y	N	N	Y	Y	Y	87
14	Ewé Àrùnpálé	*Chenopodium ambiosioides* Linn.	Chenopodiaceae	Herb	F	For treatment of headache, boil Expulsion of guinea worm from human body.	C	DL	A	R	N	Y	N	Y	N	Y	N	69
15	Ewé Akíntólá-ta-kú	*Chromolaena odorata* (Linn.) King & Robinson	Asterceae	Herb	F	For treatment of fresh wound (antihaemorrhage)	Sq	DL	D	R	N	Y	N	N	Y	Y	N	152
16	Ewé Osàn wéwé	*Citrus aurantifolia (Christm.) Swingle*	Rutaceae	Tree	F	For treatment of worms and controlling vomit in sick patients.	D	DL	D	R	N	Y	N	Y	Y	Y	N	156
17	Ewé Èpìà	*Cleome viscose* Linn.	Capparaceae	Herb	F	Used to wash the head alone for headache treatment.	C	DL	D	R	N	Y	N	N	Y	Y	Y	121
18	Ewé Ojú	*Coccinia barteri* (Hook.f.) Keay	Cucurbittaceae	Herb	F	For cough treatment.	D	DL	D	R	N	Y	N	N	Y	Y	Y	87

Source: Field Survey, 2012. PF: Plant Form, FU: Form Use, F: Fresh, MTD of P: Method of Preparation, C: Concoction, D: Decoction, Cr: Cream , Sq: Squeezed for extracts, A: All Season, Abnt: Abundant, DL: Dry land, AD: Air Dry, Av: Average, Avbty: Availability B: B: Both Dry Land and Wet Land, Cmn: Common, Ctvt: Cultivated, D: Dry Season, Ext: Extinct, H: High, HBT: Habitat, L: Low, MWL: Mostly Wet Land, N: No, PH: Period of Harvest, Psvtn: Preservation, R: Rainy season, Y: Yes, WL: Wet land

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	Local Name	Scientific Name	Family Name						Scarce	Abnt	Rare	Cmn	Ext	Wild	Ctvt	sun	AD	
19	Ewé Ògèdè odò	*Crinum jagus* (Thomps.) Dandy	Amaryllidaceae	Bulbous plant	F	For treatment of cough.	D	WL	D	R	N	Y	N	N	Y	Y	N	45
20	Ewé Kórópò	*Crotolaria retusa* Linn.	Leguminosae: Papilionoidae	Herb	F	Use to correct testis in balance in kids.	D	DL	D	R	N	Y	N	Y	Y	Y	N	34
21	Ewé Èérú	*Croton lobatus* Linn.	Euphorbiaceae	Herb	F/D	For treatment of underdeveloped pregnancy.	D	DL	A	R	N	Y	N	N	Y	Y	N	24
22	Ewé Iná	*Cucumis melo* Linn.	Cucurbitaceae	Herb	F	It is used in treating body weakness.	D	WL	D	R	N	Y	N	Y	Y	Y	N	32
23	Ewé Òjìjí	*Dalbergia lacteal* Vatke	Asteraceae	Shrub/ Tree	F	To activate movement of foetus in the womb.	C	DL	D	R	N	Y	N	N	Y	Y	Y	21
24	Ewé Àwín	*Dialium guineense* Willd.	Leguminosae: Caesalpiniodes	Tree	F	For treatment of cough	D	DL	R	D	N	Y	N	N	Y	Y	Y	45
25	Ewé Òdúndún	*Emilia coccinea* (Sims) G. Don	Asteraceae	Herb	F/D	For treatment of Asthma.	C	DL	D	R	N	Y	N	N	Y	Y	Y	29
26	Ewé Eépín	*Ficus exasperata* Vahl	Moraceae	Tree	F	For treatment of asthma, Ringworm Boil, Pain relief.	C, D	DL	D	R	N	Y	N	N	Y	Y	Y	34
27	Ewé Ìtéjú	*Gongronema latifolium* Benth.	Ascelepiadaceae	Climber	F/D	For treatment of stomach pains.	D	DL	D	R	N	Y	N	Y	N	Y	Y	32
28	Ewé Agogo igún	*Heliotropium indicum* Linn.	Boraginaceae	Herb	F	As cure of mouth infection.	Sq	DL	D	R	N	Y	N	N	Y	Y	Y	28

Source: Field Survey, 2012. PF: Plant Form, FU: Form Use, F: Fresh, F/D: Fresh & Dry, MTD of P: Method of Preparation, C: Concoction, D: Decoction, Sq: Squeezed for extracts, A: All season, Abnt: Abundant, DL: Dry land, AD: Air Dry, Av: Average, Avbty: Availability B: B: Both Dry Land and Wet Land, Cmn: Common, Ctvt: Cultivated, D: Dry Season, Ext: Extinct, H: High, HBT: Habitat, L: Low, MWL: Mostly Wet Land, N: No, PH: Period of Harvest, Psvtn: Preservation, R: Rainy season, Y: Yes, WL: Wet land

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	Local Name	Scientific Name	Family Name						Scarce	Abnt	Rare	Cmn	Ext	Wild	Ctvt	sun	AD	
29	Ewé Gbégbé	*Icacina trichanta* Oliv.	Icacinaceae	Shrub	F	For treatment of chest pain	D	WL	D	R	N	Y	N	N	Y	Y	Y	21
30	Ewé Tàgìrì	*Lagenaria breviflora* (Benth.) Roberty	Cucurbitaceae	Climber	F	For Hypertension treatment,	Sq	DL	R	D	N	Y	N	N	Y	Y	N	65
31	Ewé Opón	*Lannea welwitschii (Hiern) Engl.*	Anacardiaceae	Tree	F	For treatment of stomach pain upset (constipation)	D	DL	D	R	N	Y	N	N	Y	Y	Y	42
32	Ewé Làálì	*Lawsonia inermis* Linn.	Lytheraceae	Shrub	F	For whitlow, typhoid.	D	DL	D	R	N	Y	N	N	Y	Y	Y	85
33	Ewé Awo	*Leptoderis micrantha* Dunn	Leguminosae: Papilionoideae	Shrub	F	For treatment of boils.	Sq	DL	D	R	N	Y	N	Y	Y	Y	Y	34
34	Ewé Patanmó	*Mimosa pudica* Linn.	Leguminosae: Mimosoideae	Herb	F	Cure for stroke.	C, D	DL	D	R	N	Y	N	Y	Y	Y	Y	32
35	Ewé Inà	*Mucuna sloanei* Fawcett & Rendle	Leguminosae: Papilionoideae	Climber	F	It is use in treating body weakness.	C, Cr	DL	D	R	N	Y	N	N	Y	Y	Y	42
36	Ewé Òpépe	*Nauclea diderrichii* (De Wild. & T.Durand) Merril…	Rubiaceae	Tree/ Shrub	F	Used as blood tonic.	D	DL	D	R	N	Y	N	N	Y	Y	Y	32
37	Ewé Tábà	*Nicotiana tabacum* Linn.	Solonaceae	Herb	F	For toothache treatment.	D	DL	D	R	N	Y	N	N	Y	Y	Y	82
38	Ewé Efinrin osó	*Occimum gratissimum* Linn.	Labitaceae	Shrub	F	For treatment of severe waist pain.	Sq	DL	D	R	N	Y	N	N	Y	Y	Y	32
39	Ewé Irúgbàá	*Parkia biglobosa* (Jacq.) R. Br. ex G. Don	Leguminosae: Mimosoideae	Tree	F	Cure for stroke, Eye wash against red eye.	D	DL	D	R	N	Y	N	N	Y	Y	Y	41

Source: Field Survey, 2012. PF: Plant Form, FU: Form Use, F: Fresh, F/D: Fresh & Dry, MTD of P: Method of Preparation, C: Concoction, D: Decoction, Cr: Cream , Sq: Squeezed for extracts, Abnt: Abundant, DL: Dry land, AD: Air Dry, Av: Average, Avbty: Availability B: B: Both Dry Land and Wet Land, Cmn: Common, Ctvt: Cultivated, D: Dry Season, Ext: Extinct, H: High, HBT: Habitat, L: Low, MWL: Mostly Wet Land, N: No, PH: Period of Harvest, Psvtn: Preservation, R: Rainy season, Y: Yes, WL: Wet land

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	Local Name	Scientific Name	Family Name						Scarce	Abnt	Rare	Cmn	Ext	Wild	Ctvt	sun	AD	
40	Ewé Ogbó	*Perquetina nigrescens* (Afzel.) Bullock	Periplocaceae	Twinner	F	To ease child labour pains and as blood tonic.	C, D	DL	D	R	N	Y	N	N	Y	Y	Y	67
41	Ewé Pía	*Persea americana* Mill.	Lauraceae	Tree	F	Cure for hypertension.	D	DL	D	R	N	Y	N	N	Y	Y	Y	31
42	Ewé Sémolápá / Sèmílówó	*Portulaca quardrifida* L.	Portulacaceae	Climber	F	For stomachaches.	D	DL	D	R	N	Y	N	N	Y	Y	Y	29
43	Ewé Jìrì Ògan/Ògan Àparò	*Sabicea calycina* Benth.	Rubiaceae	Trailing-Shrub	F	For healing of wounds.	D	DL	D	R	N	Y	N	N	Y	Y	Y	41
44	Ewé Èkìkà ìyeyè	*Spondias mombin* Linn.	Anacardiaceae	Tree	F	For treatment of backache.	D	DL	D	R	N	Y	N	N	Y	Y	Y	43
45	Ewé Àgbáyun	*Syncepalum dulcificum* (schum. & Thonn.) Daniell	Sapotaceae	Shrub/ Tree	F	Cure of asthma	D	DL	D	R	N	Y	N	N	Y	Y	Y	52
46	Ewé Àìdan	*Tetraplura tetraptera* (Schum. & Thonn.) Taubert	Leguminosae: Mimosoideae	Tree	F	For treatment of Cough.	D	DL	D	R	N	Y	N	N	Y	Y	Y	43
47	Ewé Ewúro	*Vernonia amygdalina* Del.	Asteraceae	Shrub / Tree	F	For stomach pain, hypertension, wound and mouth wash.	C, D, Sq	DL	D	R	N	Y	N	N	Y	Y	Y	145

Source: Field Survey, 2012. PF: Plant Form, FU: Form Use, F: Fresh, F/D: Fresh & Dry, MTD of P: Method of Preparation, C: Concoction, D: Decoction, Sq: Squeezed for extracts, Abnt: Abundant, DL: Dry land, AD: Air Dry, Av: Average, Avbty: Availability B: B: Both Dry Land and Wet Land, Cmn: Common, Ctvt: Cultivated, D: Dry Season, Ext: Extinct, HBT: Habitat, N: No, PH: Period of Harvest, Psvtn: Preservation, R: Rainy season, Y: Yes, WL: Wet land

Table 2: Categorization of Different Types of Forest Plant Leaves Utilized for Traditional Healthcare Treatment in the Study Area

Items N= 47	Family Name	No	%	PF	No	%	Ailment Used for?	No	%	MTD of P	No	%
1	*Alliaceae*	2	4.25	B	1	2.13	Aiding Child Movement	2	4.25	C	5	10.64
2	*Amaryllidaceae*	1	2.13	C	7	14.89	Asthma	5	10.64	C, Cr	2	4.25
3	*Ampelidaceae*	1	2.13	H	16	34.04	Blood Tonic	1	2.13	C, D, Sq	1	2.13
4	*Anacardiaceae*	2	4.26	L	1	2.13	Boil	1	2.13	C,D	6	12.77
5	*Ascelepiadaceae*	2	4.26	S/T	4	8.51	Bone treatment (Fracture)	1	2.13	Cr	1	2.13
6	*Asteraceae*	5	10.64	S	6	12.77	Correction of Kids Testis	1	2.13	Cr, D	1	2.13
7	*Basellaceae*	1	2.13	Tr	11	23.4	Cough	7	14.89	D	26	55.32
8	*Bombacaceae*	1	2.13	Tw	1	2.13	Hypertension	6	12.77	Sq	5	10.64
9	*Boraginaceae*	1	2.13				Mouth Infection	2	4.25			
10	*Capparaceae*	1	2.13				Pains: Chest, Stomach, Whole body, High Body Temperature, Headache, Waist, Backache	14	29.78			
11	*Chenopoidaceae*	1	2.13				Pregnancy Development Care & Child Delivery pain	2	4.25			
12	*Crassulaceae*	1	2.13				Red Eye	1	2.13			
13	*Cucurbitaceae*	3	6.38				Ringworm Boil	2	4.25			
14	*Euphorbiaceae*	1	2.13				Sore	1	2.13			
15	*Icacinaceae*	1	2.13				Stroke	3	6.38			
16	*Labitaceae*	1	2.13				Syphills	2	4.25			
17	*Lauraceae*	2	4.26				Toothache Treatment	1	2.13			
18	*Leguminosae (Fabiaceae)*	10	21.28				Typhoid	1	2.13			
19	*Lytheraceae*	1	2.13				Ulcer	2	4.25			
20	*Menispermaceae*	1	2.13				Vomiting	1	2.13			
21	*Moraceae*	1	2.13				Whitlow	1	2.13			
22	*Periplocaceae*	1	2.13				Worms	1	2.13			
23	*Portulacaceae*	1	2.13				Wound	4	8.51			
24	*Rubiaceae*	2	4.26									
25	*Rutaceae*	1	2.13									
26	*Sapotacea*	1	2.13									
27	*Solonaceae*	1	2.13									

Source: Field Survey, 2012. MTD of P: Method of Preparation, C: Concoction, D: Decoction, Cr: Cream, Sq: Squeezed, PF: Plant Form, B: Bulbous plant, C: Climbers, H: Herb, L: Liane, S/T: Shrub/Tree, S: Shrubs, Tr: Trees, Tw: Twinner

Table 2 Cont'd.: Categorization of Different Types of Forest Plant Leaves Utilized for Traditional Healthcare Treatment

Items	FU		HBT		PH				Avbty						Srce				Psvtn			
N =					Scarce		Abnt		Rare		Cmn		Ext		Wild		Ctvt		sun		AD	
47	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%
N	-	-	-	-	-	-	-	-	46	97.87	1	2.13	47	100	38	80.85	2	4.25	1	2.13	13	27.66
Y	-	-	-	-	-	-	-	-	1	2.13	46	97.87	-	-	9	19.15	45	95.75	46	97.87	34	72.34
D	-	-	-	-	43	91.49	2	4.25	-	-	-	-	-	-	-	-	-	-	-	-	-	-
A	-	-	-	-	2	4.25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
R	-	-	-	-	2	4.25	45	95.75	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DL	-	-	37	78.72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WL	-	-	6	12.77	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MWL	-	-	2	4.25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B	-	-	2	4.25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
F	44	93.62	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
F/D	3	6.38	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Source: Field Survey, 2012. FU: Form Use, F: Fresh, Abnt: Abundant, DL: Dry land, A: All Season, AD: Air Dry, Avbty: Availability B: Both Dry Land and Wet Land, Cmn: Common, Ctvt: Cultivated, D: Dry Season, Ext: Extinct, HBT: Habitat, MWL: Mostly Wet Land, N: No, PH: Period of Harvest, Psvtn: Preservation, R: Rainy season, Y: Yes, WL: Wet land

Mechanical and physical properties of Wood Composite Panel From Recycled Plastic and Sawdust of *Cordia alliodora(Ruiz &Pav.)*

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ABSTRACT

Wood plastic composite boards were made from sawn dust of cordia alliodora and recycled polyethylene at a mixing ratio of 1.5:1, 2.5:1and 3.5:1 and nominal densities of 700kg/m^3, 800kg/m^3 and 900km/m^3. The material was hot pressed at 150^{0}c to produce board of 250mm x 250mm x 6mm of which 18 boards were produced. The experiment was subject to 3 x 3 factorial experiments in Completely Randomised Design (CRD). Analysis of variance and Duncan Multiple Range Test (DMRT) was adopted by 3 x 3 at 5% probability. The strength properties of the boards such as modulus of rupture (MOR) and modulus of elasticity (MOE) were investigated, while the dimensional properties of the board such as the water absorption (WA) and thickness swelling (TS) were as well determined after 12hrs and 24hrs of water immersion. The result showed that the mean values of MOE ranged from 9100.73N/mm^2 to 12086.96n/mm^2 while MOR values ranged from 48.26N/mm^2 to 103.09N/mm^2. The values of WA and TS after 12hrs immersion ranged from 1.21% to 1.56% and 0.00% to 0.13% , respectively. The values of WA and TS after 24hrs of water immersion ranged from 1.66% to 2.99% and 0.02% to 0.18%, respectively. The higher the value of board density and the HDPE/sawdust ratio, the stronger, the stiffer and more dimensionally stable the wood plastic composite boards obtained. In addition, as the density of the board increases, the strength property of the boards increases. Hence the board will be suitable for internal construction materials.

Keywords: Wood Plastic composite, modulus of rupture, modulus of elasticity, dimensional stability.

INTRODUCTION

Wood wastes have been a main environmental concern. Plastic is the biggest problem due to its high amount of waste generated, non-biodegradability and the fastest depletion of natural resources regarding its short life cycle, therefore increased amount of material utilized in its production, and waste generated. The same applies to wood with lesser degree where it is depleting trees and forests and the wastes mainly are either burned or disposed; resulting in extra consumption, depletion, and pollution of nature. Several worldwide attempts have been adopted; especially in the developed countries, to take advantage of these types of waste especially with the raised need for alternatives to virgin materials (*Winandy, et al.* 2004). Wood plastic composite (WPC) is a product which could be obtained from plastic and wood. WPC is a composite with a rapid growing usage consisting of a mixture of wood waste and polymeric material (*Soury, et al*. 2009).

WPC has become currently an important address of research that gained popularity over the last decade especially with its properties and advantages that attracted researchers such as: high durability, Low maintenance, acceptable relative strength and stiffness, fewer prices relative to other competing materials, and the fact that it is a natural resource (*Winandy, et al*. 2004) and Bengtsson and Oksman 2006). Other advantages have been strength points including (Wechsler and Hiziroglu 2007): the resistance in opposition to biological deterioration especially for outdoor applications where untreated timber products are not suitable, the high availability of fine particles of wood waste is a main point of attraction which guarantees sustainability, improved thermal and creep performance relative to unfilled plastics where It can be produced to obtain structural building applications including: profiles, sheathings, decking, roof tiles, and window trims. On the other hand, WPCs are not nearly as stiff as solid wood; however, they are stiffer than unfilled plastics. In addition, they do not require special fasteners or design changes in application as they perform like conventional wood (Clemons and Caufield 2005).

The paper therefore, examined the dimensional stability and physical properties such as water absorption and thickness swelling and mechanical properties such as modulus of rupture and modulus of elasticity of polymer composite board respectively

MATERIALS

Sawdust was collected from a local sawmilll at poly road, Sango, Ibadan. The fresh sawdust received was sieved with 85 sever mesh and dried at 120°C for 4 hours to a moisture content of about 2-3%. The plastic material got from the plastic craps was collected from the Black horse Ibadan. The air dried sawdust was sieved to remove the particles which were serves as wood flour and both materials were kept in the laboratory.

BOARD FORMATION

The variable for the board production with plastic and sawn dust were at 3 level, 1.5 : 1, 2.5:1 and 3.5: 1 and at a board density of 700 kg/mm^3, 800kg/mm^3 and 900kg/mm^3. The quality of the plastic and sawn dust required for a board was measured on a weighing balance. The materials were mixed thoroughly and placed in the mould; the mould was lubricated with oil for easy removal of the formed boards. The mix was hot pressed at 160^{0}c for 35 minutes and after pressing the board was allowed to cool.



Fig 1: 250mm x 250mm x 6mm Wood plastic board

MOULD

Mould used for the study consisted of aluminium frame in which the materials were laid. The size of the mould was 250 X 250 X 6mm thick.

HOT PRESS

The hot press used comprised of electrical elements at the top of the plate, a lever was present to roll up the board to the plate



Fig 2: Hot Pressing Machine

EXPERIMENTAL DESIGN

The design of the experiment includes two variables, the first is the wood plastic ratio and the second is the density. The experiment was arranged as a 3x3 factorial experiment in CRD. The combination were nine, each treatment was replicated two times, thus a total of 18 board were produced for the study

Process variables;

Density:	700, 800, 900kg/m3
Board dimension:	250mm (length) x 250(width) x 6mm(thickness)
Properties tested:	Water absorption, thickness swelling, Modulus of rupture and elasticity

TEST FOR PHYSICAL PROPERTIES

Samples of 50mm x 50mm x 6mm for the physical properties were taken randomly different parts of the boards (plate 5) according to the British standards 373(1989). The parameters that were tested are the board density, thickness swelling and water absorption.

Thickness swelling and water absorption

The specimen used for these tests were 50mm x 50mm x 6mm,the thickness of the test specimens were measured with a dial gauge to ascertain the thickness of the weight was determined according to the British standard 373 (1989). The specimens were submerged in distil water at 22^0c in a horizontal depth of 25mm for two different regimes, one hour and 24 hours according to ASTM (1987). The specimens were later removed and drained for 10 minutes to remove excess water, therefore, specimens were weighed and thickness measurement taken. Water absorption was calculated from the increase in the specimen as follows;

$$WA\% = \frac{W2 - W1}{W1} \times 100$$

Where:

WA = water absorption (%)
W2= final weight after treatment (g)
W1= initial weight after treatment (g)

$$TS\% = \frac{T2 - T1}{T1} \times 100$$

Where:

TS= thickness swelling (%)
T2=final thickness after treatment (mm)
T1= initial thickness after treatment (mm)

TEXT FOR MECHANICAL PROPERTIES

The mechanical properties that were determined include modulus 0f rupture (MOR) modulus of elasticity (MOE).

Modulus of Rupture (MOR)

Board samples were cut into 12mmx 50mm x 178mm dimension according to the British standard 373(1989) and tested on an elastic beam apparatus. The loads were applied until failure of the sample occurred. The load at which each text sample failed was recorded. The MOR was calculated using the formula.

$$MOR = \frac{3PL}{2bd^2}$$

Where;
MOR= Modulus of rupture (N/mm^2)
P=load (N)
L= the span of board sample between the machine supports (mm)
b= width of the board sample (mm)
d= thickness of the board sample (mm)

Modulus of Elasticity (MOE)

The modulus of elasticity was calculated from the values obtained from the load deflection graph during the test for MOR. The formula employed is given as MOE

$$= PL^3$$

$\frac{L^3P}{4bd^3h}$

Where;
MOE= modulus of elasticity (N/mm^2)
P= load (N)
L= The span of board sample between the machine supports (mm)
b= width of the board sample (mm)
d= thickness of the board sample (mm)
h= slope from the graph.

STATISTICAL ANALYSIS

Analysis of variance was conducted to estimate the important of failure sources of variation on the TS, WA, MOR and MOE. The main effects considered where those difference between density and the mixing ratio. The follow up test was considered at 0.05 levels to choose the best treatment combination.

Mathematical model for two-factor factorial experiment is given as
$Yijk= \mu+ Aj+Bj+(AB)ij+Eijk$
Where;
Yijk= Individual observation
μ = General mean
Aj = Effect of factor Effect of factor B
(AB)ij = Effect of interaction AB
Eijk = Experiment error.

RESULTS AND DISCUSSION

The mean values of results obtained from the tests made on the boards are presented in table 1.

PHYSICAL PROPERTIES

Thickness Swelling and Water Absorption

The mean values of 12hours and 24hours soaked tests conducted for water absorption ranged from 1.21% to 1.56% and 1.66% to 2.99% respectively. The mean values for the thickness swelling for 12hours and 24hours ranged from 0.00% to 0.13% and 0.02% to 0.18% respectively. These values were low and this indicates that the boards are slightly dimensionally stable, the range of the studies are similar to the previous studies. It shows that as plastic ratio increase the thickness swelling reduced. It was observed that as they are retained in water, they lose their strength properties.

Thickness swelling values for 12 hour and 24 hour for ratio 1.5:1 ranged from 1.64% to 2.84%, 3.39% and 4.64% respectively. Thickness swelling values for 12 hour and 24 hour for ratio 2.5:1 ranged from 1.45% to 1.70% and 1.65% to 1.97% respectively. These values are high and indicate that the board retain more water; hence water absorption increases as plastic ratio reduces. The stability performance of the boards increased in board density and plastic ratio. The observed decrease in absorption ratio of plastic-sawdust composite boards agreed with reports of (Kaplon, 1995). The high water absorption and thickness swelling values were high because there was not sufficient plastic to bind the wood particles together. Analysis of variance carried out shows that thickness swelling and water absorption were not all significant to density and plastic ratio

MECHANICAL PROPERTIES

The analysis of the variance on the bending strength and stiffness are presented in the table 1 below.

Modulus of rupture (MOR)

The mean values obtained for MOR for plastic ratio 1.5: 1 ranged from 48.16N/mm^2 to 102.27N/mm^2 while the plastic ratio 2.5:1 ranged from 91.53N/mm^2 to 115.22N/mm^2 and 3.5:1 ranged from 96.69N/mm^2 to 123.09N/mm^2.Modulus of rupture increase with increase in plastic proportion of the boards. As more plastics were introduced into the mix, there were more dimensional stable boards. Analysis of variance shows that they were significant at 0.5 confidence level.

Modulus of Elasticity (MOE)

The values obtained for MOE for plastic ratio 1.5:1 ranged from 9100.73N/mm^2 to 12213.96N/mm^2 while for 2.5:1 ranged from 9506.87N/mm^2 to 13214.89N/mm^2 and 3.5:1 ranged from 10487.19N/mm^2 to 14046.96N/mm^2. MOE also increase with plastic

ratio being higher. Analysis of variance shows that they were significant to density and the wood plastic ratio, though the plastic still has influence on MOE.

Table 1: Mean values of physical properties and mechanical properties of wood composite board produced from recycled polyethylene and sawdust

DENSITY Kg/m^3	MRL	WA-12HRS	WA-24HRS	TS-12HRS	TS-24HRS	MOR N/mm^2	MOE N/mm^2
700	1.5:1	1.56±0.77	2.99±0.01	0.13±0.01	0.18±0.03	78.26±0.01	9200.73
	2.5:1	1.54±0.78	2.42±0.46	0.08±0.12	0.11±0.03	91.53±0.94	9506.87
	3.5:1	1.50±0.65	2.40±0.65	0.04±0.05	0.05±0.02	96.69±2.15	10487.19
800	1.5:1	1.12±0.02	2.18±0.04	0.00±0.04	0.07±0.04	98.69±0.62	10235.96
	2.5:1	1.10±1.08	2.12±0.03	0.00±0.02	0.03±0.12	98.61±0.69	10616.17
	3.5:1	1.10±0.00	1.79±0.30	0.00±0.01	0.02±0.08	103.19±1.45	11521.75
900	1.5:1	2.44±0.45	2.34±0.36	0.00±0.00	0.05±0.02	102.27±0.07	12213.96
	2.5:1	1.62±0.69	2.01±0.01	0.00±0.00	0.03±0.03	115.22±0.63	13214.89
	3.5:1	1.21±0.00	1.66±0.61	0.00±0.00	0.02±0.12	123.09±0.89	14046.9

Table2: Result of analysis for the data obtained for properties evaluated Variance ration (P-value at 0.05)

Source of variance	Df	TS% 12hrs	TS (%) 24hrs	WA (%) 12hrs	WA (%) 24hrs	MOE	MOR
Density	2	0.933^{NS}	0.144^{NS}	0.958^{NS}	1.372^{NS}	6637.81^{*}	857.39^{*}
Mixing ratio	2	3.935^{NS}	2.070^{NS}	0.650^{NS}	2.552^{NS}	1183.49^{*}	330.89^{*}
Trt combination	4	9.411^{*}	5.359^{*}	0.722^{NS}	0.178^{NS}	30.04^{*}	32.13^{*}
Error	9						
Total	17						

Table 3: The result of DMRT carried out at 5% level of significance, showing the effect of density on the dimensional properties of the wood plastic board

Density	TS (%) 12hrs	TS (%) 24hrs	WA (%) 12hrs	WA (%) 24hrs	MOE	MOR
700	0.07^{a}	0.12^{a}	1.59^{a}	2.33^{a}	9731.59^{a}	88.83^{a}
800	0.07^{a}	0.12^{a}	2.08^{a}	2.03^{a}	10791.49^{a}	99.49^{a}
900	0.43^{a}	0.65^{a}	1.76^{a}	2.01^{a}	13158.60^{a}	113.52^{a}

The same subscript letter is not significantly different at 0.05

Table 4: The result of DMRT carried out at 5% level of significance, showing the effect of mixing ratio on the dimensional properties of the wood plastic board

MR	TS(%) 12hrs	TS(%) 24hrs	WA(%) 12hrs	WA(%) 24hrs	MOE	MOE
1.5:1	0.06^{b}	0.10^{a}	2.04^{a}	1.85^{a}	10550.22^{a}	92.49^{a}
2.5:1	0.03^{a}	0.11^{a}	1.72^{a}	2.23^{a}	11112.64^{b}	101.78^{b}
3.5:1	0.09^{b}	0.12^{a}	1.66^{a}	2.19^{a}	12018.63^{c}	107.66^{c}

The same subscript letter is not significantly different at 0.05

CONCLUSION AND RECOMMENDATIONS

Conclusion

The study showed the potentials of recycled polyethylene materials for wood plastic composite production. The properties assessed also showed that WPC produced from recycled polyethylene materials are lower when compared with other panel products. The WPC produced showed high moisture resistant and could be used for roofing, ceiling, partitioning, flooring and other applications that may require low dimensional properties particularly in an area of little or no threat of extreme moisture variations. The use of these two materials for WPC would assist in reducing environmental pollution such as flood and low cost effectiveness for panel product industries that might be interested in the production. This will also contribute to the effort of Federal Government in alleviating poverty and creating wealth opportunity, which is in line with Federal Government seven point agendas.

Recommendations

- Efforts should be made to extend research work on wood plastic composite boards using state of the hearth machines.
- Production of such boards using coconut, coffee shafts and so on should be incorporated
- The products can be extruded into shapes on customer's tastes.

REFERENCES

Adhikary: "Dimensional stability and mechanical behavior of wood– plastic composites based on recycled and virgin high-density polyethylene (HDPE)." Composites: Part B, no. 39 (2008): 807–815.

Allsopp M. W., Vianello G., (2012), "Poly(Vinyl Chloride)" in Ullmann's Encyclopedia of Industrial Chemistry, 2012, Wiley-VCH, Weinheim

American Chemistry Council, Inc. Retrieved 24 December (2012): "Common Plastic Resins Used in Packaging". Introduction to Plastics Science Teaching Resources.

ANSI (American National Standards Institute) (1999) American National Standard for Particleboard. ANSI/A208.1. Composite Panel Association, Gaithersburg, MD

Augutis: "Testing system for composite wood based strips."Measurement Technologies Laboratory (Faculty of Telecommunications and Electronics), no. Issue 285 (2004).

Ayrilmis N, Jarusombuti S (2011) Flat-pressed wood plastic composite as an alternative to conventional wood-based panels. J Compos Mater

Ayrilmis N, Jarusombuti S, Fueangvivat V, Bauchongkol P (2011) Effect of thermal-treatment of wood fibres on properties of flat-pressed wood plastic composites. Polym Degrad Stabil 96:818-82

Bengtsson, and Kristiina Oksman: "Silane crosslinked wood plastic composites: Processing and properties." Composites Science and Technology, no. 66 (2006): 2177–2186.

Benj Edwards, (2007) Vintage Computing and Gaming | Archive » Why Super Nintendos Lose Their Color: Plastic Discoloration in Classic Machines. Vintage computing.

Boedeker Plastics: How to identify plastic materials using the burn test"..Retrieved 8 May 2012.Kenneth S. Whiteley, T. Geoffrey Heggs, Hartmut Koch, Ralph L. Mawer, Wolfgang Immel, "Polyolefins" in Ullmann's Encyclopedia of Industrial Chemistry 2005, Wiley-VCH, Weinheim.

Bouafif: "Effects of fiber characteristics on the physical and mechanical properties." Composites: Part A, 2009.

Chen HC, Chen TY, Hsu CH (2006) Effects of wood particle size and mixing ratios of HDPE on the properties of the composites Clemons and Daniel F. Caufield: "Wood Flour." In Functional Fillers for Plastics, by Craig M. Clemons and Daniel F. Caufield, edited by M. Xantos, 249-270. Federal Republic of Germany: The Forest Products Laboratory, 2005.

Clemons: "Effects of processing method and moisture history on laboratory fungal resistance of wood-HDPE composites." Forest Products Journal 4, no. 54 (2004): 50-57.

Falk: "Wood recycling: Opportunities for the wood waste resource." Forest Products Journal 6, no. 47 (1997): 17-21.

Gupta BS, Reiniati I, Laborie MPG (2007) Surface properties and adhesion of wood fiber reinforced thermoplastic composites

Klyosov, Anatole A. Wood-Plastic Composites. New Jersey: John Wiley & Sons, Inc., 2007.

Maul J., Frushour B. G., Kontoff J. R., Eichenauer H., Ott K.-H., Schade C., (2007): Polystyrene and Styrene Copolymers" in Ullmann's Encyclopedia of Industrial Chemistry 2007 Wiley- VCH, Weinheim

McDonough, W., and Braungart M., Cradle to Cradle: Remaking the way we make things. North point press, DuraBook, 2002.

Migneault: "Effects of processing method and fiber size on the structure and properties." Composites: Part A, no. 40 (2009):80-85.

Morton and Rossi L., "Current and Emerging Applications for Natural and Wood Fiber Composites." 7th International Conference on Woodfiber-Plastic Composites. Madison, WI: Forest Products Society, 2003.

Najafi:. "Effect of temperature, plastic type and virginity on the water uptake of sawdust/plastic composites." Holz Roh Werkst, no. 65 (2007): 377–382.Piringer & Baner 2008

Rutkowski, J. V.; Levin, B. C. (1986). "Acrylonitrile-butadiene-styrene copolymers (ABS): Pyrolysis and combustion products and their toxicity?a review of the literature

Shibata M, Takachiyo K, Ozawa K, Yosomiya R, Takeishi H (2002) Biodegradable polyester composites reinforced with short abaca fiber. J Appl Polym Sci 85:129-138

Soury: "Design, optimization and manufacturing of wood–plastic composite pallet." Materials and Design, no. 30 (2009): 4183–4191.Stratasys Inc.,(2007)

Takatani: "Cellulose esters as compatibilizers in wood/poly (lactic acid) composite." The Japan Wood Research Society, no. 54 (2007):54-61.

The McGraw-Hill, Charles A. Harper,(2002):Handbook of Plastics, Elastomers, and Composites, Fourth Edition.

Titow W. V., (1984). PVC technology. Springer. pp. 6–. ISBN 978-0- 85334-249-6. Retrieved 6 October 2011.

Wechsler, A., and Hiziroglu S., Building and Environment 42 (2007): 2637–2644.

Winandy: "Consideration In Recycling Of Wood-Plastic Composites." 5th Global Wood and Natural Fiber Composites Symposium. Kassel-Germany, 2004.

Yeh: "Wood–plastic composites formulated with virgin and recycled ABS." Composites Science and Technology, no. 69(2009): 2225–2230.

Youngquist: Lignocellulosic – Plastic Composites from Recycled materials. American Chemical Society, 1992.

Hydrophobicity and Dimensional Stability of Chemically Modified *Triplochiton scleroxylon* K. SCHUM WOOD

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ABSTRACT

Chemical modification of wood with acetic anhydride is an environmentally friendly process that can be used to sustain and improve native wood properties over a longer term than naturally allowed process. Such characteristics offer many potential and attractive product avenues for the wood industry. In this study, Triplochiton scleroxylon was acetylated with acetic anhydride to improve its physical properties relative to unmodified wood such as dimensional stability in terms of volumetric swelling (VS) and hydrophobicity in terms of contact angle (CA). The reaction was carried out at 120 °C with five varying reaction times (1-5 h) to optimize the reaction time based on weight gain percentage (WGP). The chemically modified wood was characterized by Fourier Transform- Infrared (FT –IR) spectroscopy and dynamic contact angle analyzer to observe the improvement properties of modified wood. As the reaction time increased, the WPG and CA increased but there was decrease in volumetric swelling. The highest WPG was 22.7% at 5 h and lowest (10.4%) at 1 h. The mean values obtained for volumetric swelling for the 5 h acetylated wood was lowest (2.2%) and highest (10.0%) for untreated wood blocks. The CA of untreated samples dropped from 62.25º to 3.86º while the highest contact angle was observed in 5 h acetylated samples which ranged from 93.31-87.10º. In total, acetylation provided Triplochiton scleroxylon wood with good dimensional stability and hydrophobicity.

Keywords: *Triplochiton scleroxylon*, acetic anhydride, swelling, shrinkage, contact angle, FT-IR.

INTRODUCTION

Wood is a natural and renewable raw material with a low processing energy demand that is both recyclable and biodegradable (Bruce and Lucy, 2006). It possesses porous structures consisting of various cell walls, which are mainly composed of biopolymers, i.e. carbohydrate polymers of cellulose and hemicelluloses and phenolic polymers of lignin. This cellular structure endows wood with a high strength to weight ratio, thus making, some high-quality wood suitable for use as structural materials (Sun and Sun, 2002). Wood has been used for construction, tools, furniture and artistic medium for thousands of years due to its high strength-to-weight ratio, unique porous structure, and aesthetic characteristics (Beaudoin *et al*., 1992). However, wood components are easily degraded by microorganisms, particularly at high moisture level (Fuller *et al*., 1997). Wood changes dimensions with changing moisture content due to the presence of hydroxyl and other oxygen-containing groups in the cell wall polymers that attract moisture through hydrogen bonding (Rowell, 2014). The hygroscopic character of this group can result in wood with poor dimensional stability. In other words, wood shrinks as it dries and swells when it wet. These fluctuations and instabilities limit the application of wood as high-quality materials (Alfred, 1977). Many methods have been used to minimize the dimensional instabilities that occurs in wood but wood modification has proved to be effective. Various types of wood modification are possible e.g. thermal, resin impregnation, surface modification and chemical modification (Hill, 2006), but this work is concerned with chemical modification of wood and specifically acetylation.

A chemical modification reaction involves the formation of a chemical bond between the reagent and the cell wall polymers of wood. This reaction occurs between some of the hydroxyl groups of these polymers and the reagent molecules which eventually lead to a change in the chemical and physical properties of the substrate (Rowell *et al*., 1988). There are many types of chemical modification of wood but acetylation with acetic anhydride is considered to be one of the most promising ways of enhancing wood properties (Hon, 1996; Hill, 2006). According to this technique, one hydroxyl group (-OH) of wood is substituted by a radical CH_3COO of an anhydride acetic molecule $(CH_3CO)_2$ O. This substitute reduces the number of free positions of –OH that can react with water molecules thereby reducing the hygroscopicity of wood. It has been established that reductions in hygroscopicity and improved dimensional stability of acetylated wood depends on esterification of the accessible polymers in the cell wall reducing hydrogen bonding with water and bulking the cell wall back to its green volume (Rowell *et al*., 2009; Papadopoulous, 2006). Effectiveness of chemical modification of the cell wall polymers of wood to increase dimensional stability, hydrophobicity, UV resistance and biological resistance in wood has been proved by many researchers (Rowell, 2005; Hill, 2006; Mastuda, 1996; Williams, 2005; Chang and Chang, 2006; Mohebby, 2010). Most of the previous studies on acetylation have been on the use of softwoods (Foster, 1998; Rowell, 2006; Papadopoulos, 2006; Papadopoulos and Pougioula, 2010; Jebrane, *et al*., 2011) which are not native of countries with tropical weather. Some acetylation of hardwood species has also been reported even

though most hardwood species tend to be durable and dimensionally stable (Fojutowski *et al.*, 2013; Nilgul, 2007). However, there are some tropical hardwood species that are less durable and dimensionally unstable. Only few has reported acetylation of hardwood species of tropical origin (Blanco and Alfaro, 2014; Oluyinka, *et al.*, 2015). Therefore, in this study, a fast growing tropical hardwood species, found in West Africa, namely *Triplochiton scleroxylon* K. Schum, was chemically modified in order to improve the scope of its utilization. It is known in Nigeria as Obeche and it is one of the high profit and most successful indigenous tree species in the Nigerian timber market (FAO, 2002).

MATERIALS AND METHODS

Wood Preparation and Modification Procedures

Wood bolts were obtained from a 22 year old Obeche (*Triplochiton scleroxylon*) and sectioned to 20 × 20 × 300 mm (radial x tangential x longitudinal) coupons. The resultant coupons were further converted to specimens with dimensions of 20 × 20 × 60 mm (radial × tangential × longitudinal) of which samples with no defects were selected. The specimens were weighed and their masses recorded, oven dried at 105±2°C, cooled over silica gel in a desiccators, and then weighed again to determine their moisture content before modification.

Standard methods were used for the acetylation of wood specimen (Anne-Marie et al., 1987 and Giotra, 2009). Wood samples of approximately 8% moisture content were added to a stainless steel pressure reactor vessel containing acetic anhydride and acetic acid (92:8) after which the temperature was set to 25 °C and 10-15 bar of pressure was applied for 30 minutes to impregnate the wood. Excess acetylation fluid was removed from the vessel and nitrogen gas was introduced as the inert medium to control the internal temperature of the wood. The reaction's temperature was fixed at 120 °C for various periods of time (1 to 5 h) to attain different impregnation levels. When the temperature of the circulating fluid reached approximately 60 °C, the acetylation of the wood began. This was shown by an increasingly rapid rise in temperature as measured by thermocouples in the reaction vessel. Heat generated by the circulating fluid increased the temperature inside the wood to about 130-135 °C for around 15minutes. It was necessary to condense the acetic acid acetic anhydride vapour to control the pressure and temperature inside the reaction vessel before reaching 120 °C. At the end of the acetylation reaction, the reaction was quenched by cooling the reactor in an ice bath; the wood samples were washed several times, and then soaked in distilled water for 24 h. The wood samples were then air dried and oven dried at 105±2 °C for 24 h to remove remaining acetic acid. The average weight percent gain (WPG) was calculated for each batch of experimental samples.

Weight Per cent Gain

The weight per cent gain (WPG) of the wood samples after the treatment was measured on an oven dry basis. The specimens were weighed, dimensions measured with a digital calliper, and then oven-dried at 105±2 °C before and after treatment until a constant weight was achieved. They were cooled over a silica gel desiccators and weighed at an accuracy of ±0.001 g. WPG was calculated according to equation 1 which gives an averaged relative change in the oven-dry weight and volume of the tested specimens from the treatments. Ten (10) replicates of treated and untreated specimens were used to determine the WGP.

$$\text{WPG (\%)} = \frac{W_2 - W_1}{W_1} \times 100 \qquad (1)$$

Where,
W_1 = Oven-dry weight of samples before treatment, (g)
W_2 = Oven-dry weight of samples after treatment, (g)

Estimation of Dimensional Stability

Anti-swell efficiency (ASE) and Anti-shrink efficiency (ASE) for both untreated and acetylated wood samples were measured according to ASTM-1037 (1999). Five oven-dry specimens for each treatment with dimensions 20 × 20 ×10 mm were soaked in a water bath at a temperature of 20±1 °C for 168 h; weight and dimension of specimens were determined before and after soaking. Anti-swell/shrink efficiency was calculated according to Equations (2) and (3)

$$\text{ASE (\%)} = \left(\frac{S_u - S_m}{S_u}\right) \times 100 \qquad (2)$$

Where,
ASE = Anti-Swell/shrink Efficiency
S_u = Volumetric swelling coefficient of unmodified wood samples
S_m = Volumetric swelling coefficient of modified wood samples
Volumetric swelling coefficient (S) was calculated as follows:

$$\text{S (\%)} = \frac{V_2 - V_1}{V_1} \times 100 \qquad (3)$$

Where,
V_1 = volume of wood before soaking
V_2 = volume of wood after soaking

However, radial and tangential swelling/shrinkage using Equation (3) whereby the volume of the modified and unmodified wood samples were taken in radial and tangential positions.

Measurement of Dynamic Contact Angle

The contact angles of the reference liquids on the acetylated and untreated wood specimens were determined using a Phoenix 300 Contact Angle Analyser. Deionized water and diiodomethane were used as the probe fluids. The specimens were of dimension 20 × 20 × 10 mm and the cross section was sanded to obtain a smooth surface. Measurement of contact angle was done with a water droplet of 4µm in volume. The system was equipped with a camera capable of taking pictures as the water drops on the specimen.

FT-IR

The acetylated and unmodified samples were ground in a Wiley Mill machine and sieved to a 40-mesh particle size. Extractives-free wood samples were prepared using acetone and hot water following a standard method (TAPPI T264 CM97, Oct.2007) for FT-IR spectrophotometry. The IR spectra of the acetylated and unmodified samples were obtained using an ATR technique using a Perkin-Elmer FT-IR Frontier spectrophotometer by accumulation of 64 scans with a resolution of 4 cm^{-1} at 600- 4,000 cm^{-1}.

Statistical analysis

Data obtained in the study were analysed using analysis of variance (ANOVA). Treatment means were separated using the Duncan Multiple Range test at $\alpha = 0.05$.

RESULTS AND DISCUSSION

Weight Percent Gain

The extent of reaction of acetic anhydride with wood is invariably reported as acetyl weight percent gain abbreviates as WPG. Table 1 shows the effects of the reaction time on the WPG of acetylated specimens. The WPG increased with the increased reaction time. The highest WPG was found 22.74% when wood was acetylated for 300 minutes. WPG of other acetylated woods were found to be 10.37, 14.09, 18.37 and 19.06% for 60, 120, 180, and 240 minutes respectively. WPG is an important indicator that chemical reaction has occurred inside the cell walls rather than just within the cell lumens. Thus, wood not only gained weight but also swelled the chemically acetyl group occupy space in the cell wall (Hill, 2006). Different levels of WPG were achieved in the wood samples by varying the acetylation time i.e. the reaction time and linear relationships were established for reaction time and WPG. Blanco and Alfaro (2014) reported a WPG of 11.96% and 12.18% for hardwood species, *Callophyllum brasiliense* (Cedar Mary) and *Enterolobium cyclocarpum* (Guanacaste) respectively at reaction time of 420 min at 90^{o}C. These results showed that even at higher reaction time but lower reaction temperature, higher weight percent gain could not be attained. The results obtained in this study is in line with what 29 reported that an increase in WPG for wood sawdust was found after 5 h of treatment with organic anhydride. This indicated that a higher reaction temperature could give rise to a higher WPG. This latter result was attributed to morphological and structural characteristics and degradation of the wood samples.

Table 1: Weight percent gain (WPG) of acetylated and untreated *Triplochiton scleroxylon* wood specimens at various reaction times

Reaction time (min)	WPG
Untreated	-
60	10.37(0.9)^{a}
120	14.09(1.27)^{b}
180	18.37(0.52)^{c}
240	19.06(0.85)^{c}
300	22.74(1.42)^{d}

Standard deviations are in parenthesis. Means with the same superscript letters in the same column are not significantly different from each other at $\alpha = 0.05$

FT-IR ANALYSIS

Esterification between the hydroxyl groups in wood and acetic anhydride was evidenced by IR spectroscopy as shown in Figure 1. The increase of the number of acetyl groups can be followed in the infrared spectra. Three major strong peaks were observed in the acetylated wood compared to non-acetylated ones. The peaks are carbonyl (C=O) stretch region occurring at (1738–1730),

carbon–hydrogen (C- H) bond increase occurring around 1375-1370 cm^{-1}, and carbon-oxygen (C–O) stretch occurring at (1245–1000cm^{-1}) (Jebrane *et al*., 2011). The strong band of the carbonyl group at 1738-1730 cm^{-1} in all the treated samples showed that some of the hydroxyl functional groups (-OH) in the wood has been replaced by the acetyl groups. The intensity of these peaks increased with increase in acetylation times which is in accordance to what has been reported in literature (Moheeby, 2008; Blanco and Alfaro, 2014). The C-H at 1370 in acetylated wood is due to deformation of methyl groups in cellulose and hemicellulose (Evans *et al.*, 1992). There was also an increase in this band due to acetylation. The (C–O) stretch that occurred at (1245–1000cm^{-1}) is due to carbonyl deformation in the ester bonds in lignin and xylan during the acetylation which also increases with longer reaction time (Moheeby, 2008; Blanco and Alfaro, 2014).

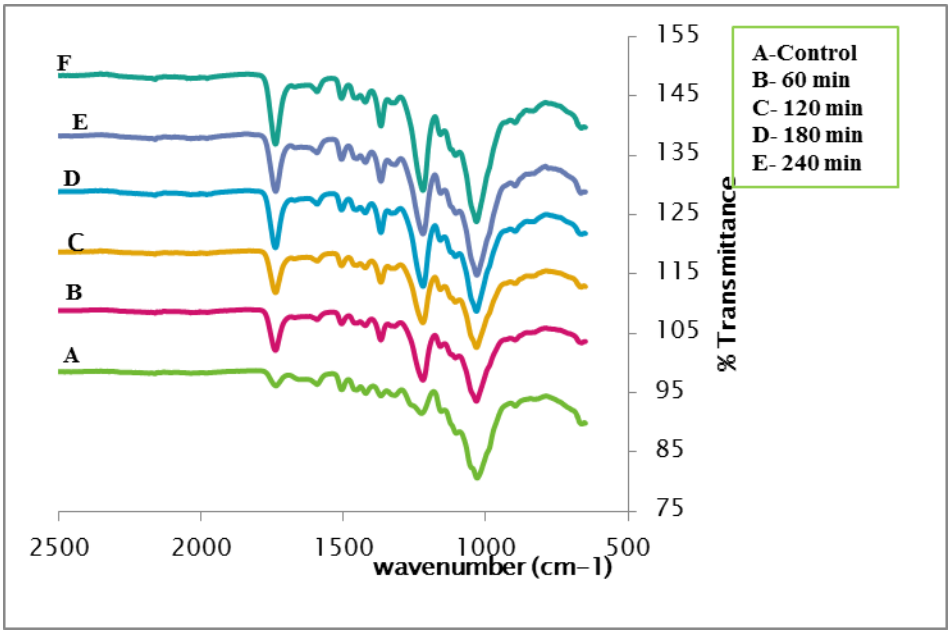


Figure 1: FT-IR (ATR) spectra of acetylated and untreated *Triplochiton scleroxylon* wood.

Swelling and Shrinkage

The results of volumetric, radial and tangential swelling of acetylated and untreated samples are presented graphically in Figure 2. Volumetric swelling was 10.01% for untreated samples and reduced to values between 2.18-6.21% for the acetylated samples. The volumetric swelling also reduced with increase in acetylation time. Radial and tangential swellings for untreated samples were 2.44 and 4.51% respectively. The radial swelling and tangential swelling for the acetylated samples ranged between 0.6-1.6 % and 1.0-4.5 % respectively. The maximum decrease in volumetric swelling, radial and tangential swelling was noted in wood acetylated for 300 min. The volumetric shrinkage, radial and tangential shrinkage for the untreated samples are 10.16 %, 2.82 % and 5.81 % respectively (Figure 3). There was a significant reduction in these values for the acetylated samples. The volumetric shrinkage for samples acetylated 60, 120,180 and 240 min were 7.83 %, 5.57 %, 3.49 % and 3.22 % respectively. The maximum reduction in volumetric shrinkage was noted at 300 min acetylated samples. The results indicated that volumetric shrinkage decreases with increase in acetylation time. Likewise, this same trend was also noticed in radial and tangential shrinkage where the wood acetylated for 300 min had the lowest radial and tangential shrinkage of 0.62 and 1.15 % respectively. It is observed that the tangential shrinkage is twice or more than the radial shrinkage both in untreated and treated samples. Statistical analysis revealed that shrinkage, radial and tangential shrinkage of the control was significantly higher than the acetylated samples.

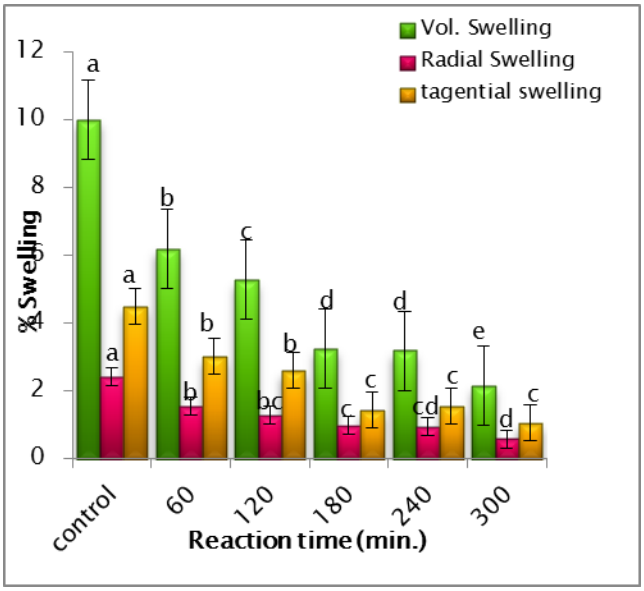


Figure 2: Volumetric, radial and tangential swelling of acetylated and untreated *Triplochiton scleroxylon* wood

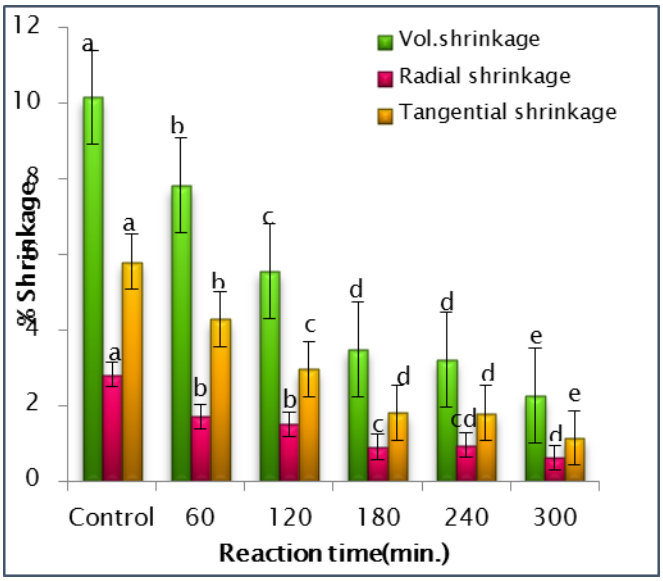


Figure 3: Volumetric, radial and tangential shrinkage of acetylated and untreated *Triplochiton scleroxylon* wood.

The shrinkage and swelling observed in untreated samples of Obeche were significantly higher than the acetylated wood samples. Acetylation brought reduction in the swelling and shrinkage of Obeche wood samples in all directions. As the WPG increases volumetric swelling and shrinkage reduces. Higher shrinkage's and swelling's reduction is seen in radial direction than in tangential direction. These results are similar to those reported by Rowel *et al.*, 2005; Olayinka *et al.*, 2014 for acetylated wood. Acetylation imparted increased dimensional stability of wood due to incorporation of acetyl groups in the cell wall. Thus, when wood is acetylated, it is far less susceptible to swelling and shrinkage. This is due to reduction of hydroxyl groups after acetylation of wood because the cell wall is now filled with chemically bonded acetyl groups which have replaced the hydroxyls groups (Rowel *et al.*, 2009). As a consequence the wood is already in a swollen condition, the extent of which depends on level of modification, thereby causing little swelling when such wood is in contact with water.

Contact Angles

A series of contact angle measurements was conducted to determine the hydrophobicity of the wood samples. Contact angles of acetylated and untreated wood samples were measured immediately after 1, 10, 20 and 30 seconds using the Sessile Drop (SD) device with two different probe liquids (Water and Diiodomethane). The results of the contact angles (CAs) for reference liquids of water and diiodomethane of acetylated samples under different acetylating levels for the samples relative to their controls are presented in Figure 4. Contact angle measurements with distilled water on wood samples gave largest contact angle values compared to the other probe liquid. The results showed that the contact angles of water and diiodomethane on the control samples immediately after the drop ranged from 62.25 - 3.86° and 22.01- 10.03° respectively. For the 60 min acetylated samples, the contact angles for water and diiodomethane ranged from 80.90 – 32.27° and 30.23 – 18.08° respectively. The 300 min acetylated

samples had the highest contact angles, for water and diiodomethane which ranged from 93.31-87.10° and 53.56 – 45.97° respectively followed by 240, 180, and 120 min as presented in table 4.18. The CAs for wood samples at 1 sec was significantly higher than the ones at 10 sec and the CAs at 10 sec were significantly higher than the one at 20 and 30 sec for all the wood samples both for water and diiodomethane. The contact angles increases with increase in reaction time. This shows that water had a higher affinity for the untreated wood sample surfaces than the treated ones.

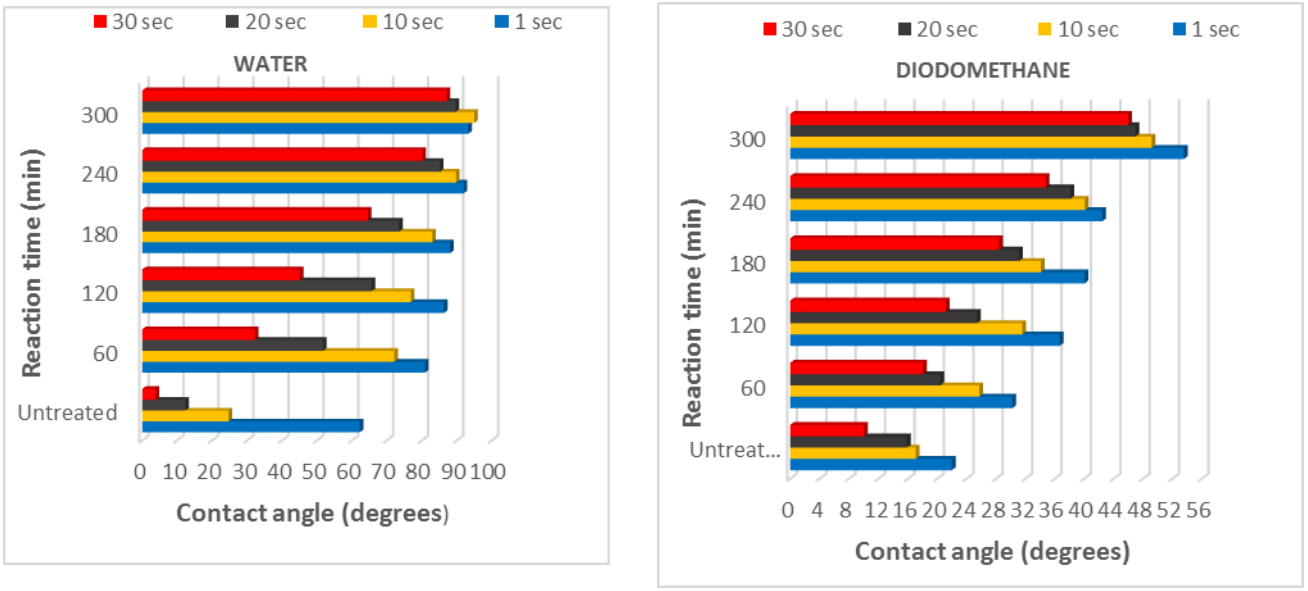


Figure 4: Contact angles for the acetylated and untreated *Triplochiton scleroxylon* wood

It can be observed that the CAs increased with increase in acetylation time. Higher reaction times gave rise to higher WPGs, consequently higher contact angles. This is due to incorporation of acetyl groups into the cell walls thereby making the wood surface hydrophobic. Acetylation increased hydrophobicity of modified wood of Obeche and caused increase of the contact angle. As it has been indicated in the results, the acetylated wood samples initially showed much hydrophobic behaviour seen as higher contact angle; however, it was later turned to less hydrophobic due to reduction of the contact angle as the evolution time was extended in all the samples according to their WPG. These results are similar to what was found in the literature Mohebby *et al*., 2010) who reported reaction time has an effect on the contact angles of acetylated nanobrillated cellulose. Different contact angles of untreated and modified wood samples at different reaction times can be attributed to the physical properties of wood surfaces. Contact angle is a function of the interfacial surface tension of wood. When the forces of attraction (surface tension) that make up the liquid are overcome by the surface energy of the wood, then the liquid spreads on the wood and wets it. If the force of surface tension is not able to overcome adhesion, the liquid droplets will maintain their spherical shape, to result in an increase in the contact angle. Therefore, in the former case, the sample behaves as a hydrophilic material and in the latter case it behaves as a hydrophobic material.

CONCLUSION

Acetylation of *T. scleroxylon* wood at different reaction times resulted in different weight percent gain with highest at 300 minutes reation time. Volumetric swelling of wood reduces as the reaction time increases whereas contact angle between the water and the wood samples increases with increase in reaction time. Therefore, dimensional stability and hydrophobicity of the wood samples were greatly improved by acetylation.

REFERENCES

Alfred, J. 1977. Wood Technology: Chemical Aspects, American Chemical Society, Washington, DC, pp. 115-140.

Anne-Marie, T., Rune, S. and Roger, R. 1987. Dimensional stability and resistance to biological degradation of wood products by a simplified acetylation procedure. *Proceedings of the 4th International Symposium of Wood and Pulping Chemistry. 27-30th April 1987*. Paris, France. 125-129.

Beaudoin, M., Hernández, R. E., Koubaa, A., Poliquin, J., 1992. Interclonal, intraclonal and within-tree variation in wood density of poplar hybrid clones. *Wood Fiber Sci*. **24:** 147–153.

Blanco, E., Alfaro J. 2014.Chemical modification of Calophyllum brasiliense Cambess. and Enterolobium cyclocarpum (Jacq.) Griseb. Wood Colombia Forestal **17(1)**: 125 – 132.

Bruce, L. and Lucy, E. 2006. Environmental performance improvement in residential construction: The impact of products, biofuels, and processes. *Forest Products Journal* 56, 58.

Chang, H. T. Chang S.T. 2002. Moisture excluding efficiency and dimensional stability ofwood improved by acetylation. *Bioresource Technology*. **85**:201-204

Evans P. D., A .J. Micehll, Schmalzl, K. J. 1992: Studies of the degradation and protection of wood surfaces; *Wood Science and Technology*. **26**: 151-163.

FAO 2002. *Hardwood plantations in Ghana* by F. Odoom. Forest Plantations Working Paper 24. Forest Resources Development Service, Forest Resources Division. FAO, Rome.

Fojutowski A., Anna K. , Aleksandra K. , Andrzej, N. 2013. The susceptibility of some acetylated hardwood species to mould fungi attack: An attempt to objectify the assessment. International biodeterioration and biodegradation **86:** 60-65

Forster, S. C. 1998. Decay resistance of modified softwood. Ph.D thesis. University of Wales, Bangor.

Fuller, B., Ellis, W., Rowell, R. 1997. Hardened and Fire Retardant Wood Products. US Patent 5605767.

Giotra, K. Patent. 2009. Process for wood acetylation and product thereof. Tiatan wood Ltd.WO2009095687.

Hill, C. A. S 2006. 'Wood modification: Chemical, thermal and other processes.' (John Wiley &Sons Chichester

Hon, D. 1996. Chemical Modification of Lignocellulosic Materials, In: CRC Press, 1-370, ISBN: 0824794729.

Jebrane, M., Pichavant, F., and Sebe, G. 2011. A comparative study on the acety-lation of wood by reaction with vinyl acetate and acetic anhydride. *Carbohydrate Polymers*, **83**: 339–345.

Matsuda, H. 1996. Chemical modification of solid wood. In: D.N.S. Hon (ed.) Chemical modification of lignocellulosic materials; Marcel Dekker, Inc.; New York, Basel, Hong Kong: P. 159-183.

Mohebby, B. Younesi, H., Ghotbifar, A. and Kazeimi-Najafis, S. 2010. " Water and moisture absorption and thickness swelling behaviour in polypropylene/wood flour/glass fiber hybrid composites" *J. Reinforce. Plast. Compos.* **29(6)**:830-839, DOI:10:11771073168440810070 2.

Moheeby, B. 2008. Application of ATR Infrared Spectroscopy in Wood Acetylation. J. *Agric. Sci. Technol*. **10**: 253-259.

Nilgul O., 2007. Dimensional Stabilisation of Fast Growing Forest Species by Acetylation. *Journal of Applied Sciences***. 7:** 710-714.

Oluyinka S., IdowuAdekunle,O., Fabiyi, J. S., Oluyege, A. O. 2015. Effect of thermal and chemicalmodifications on the dimensional stability of *Triplochiton scleroxylon* (Obeche) wood. *MSAIJ*. **13(3)**

Papadopoulos, A. N., 2006. Chemical modification of Pine wood with propionic anhydride: effect of water vapour and sorption. *BioResources* **1(1)**: 67-74

Papadopoulos, A. N., Pougioula, G. 2010. Mechanical behaviour of pine wood chemically modified with a homologous series of linear chain carboxylic acid anhydrides. *Bioresources* **101**:6147–6150

Rowell R. M., Youngquist J. A. and Montrey H. M. 1988. Chemical modification: adding value through new FPL composite processing technology. *Forest Products Journal*. **38(7/8)**:67-70.

Rowell, R. M. 2006. Acetylation. *Forest Product Journal* **56**: 4-12.

Rowell, R. M,. Ibach R. E. , Mcsweeny J., Nilsson T. 2009. Understanding decay resistance, dimensional stability and strength changes in heat-treated and acetylated wood. *Wood Material Science and Engineering.* **1-2**: 14-22

Rowell, R. M. 2005."Chemical modification of wood". In handbook of wood chemistry and wood composite, Rowell, R.M.(Ed),Taylor and Francis, CRC Press,381- 420

Rowell, R. M., 2014. Acetylated wood - A review. *International Journal of Ligninocellulosic products*. **1(1):**1-28

Sun, R. C. and Sun, X. F. 2002. Structural and thermal characterization of acetylated rice, wheat, rye, and barley straws and poplar wood fibre. *Ind. Crops Prod*. **16**, 225–235.

Williams R.S. 2005.Weathering of wood, In handbook of wood chemistry and wood composite, Rowell, R.M.(Ed),Taylor and Francis, CRC Press, 139-185

Technical Rotation age for Naturally-Grown *Bambusa vulgaris* for Fuelwood, Fibre and Structural Application

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ABSTRACT

Basic properties of Bambusa vulgaris from different ages were examined to determine the optimum technical growth rotation for fuelwood, source of fibre and structural application. Bamboo culm samples aged 2, 3 and 4 years were taken from naturally growing bamboo stock in the Campus of the Federal University of Technology, Akure, Nigeria. The density, porosity, shrinkage, swelling, fibre morphology and derived fibre values obtained from the geometry of the fibre, the fuel, chemical as well as the strength properties were determined. All the tests were conducted following the standards of Technical Association of Pulp and paper Industry (TAPPI) and American standard for testing materials (ASTM). The results showed that the maximum density (877.23Kg/m3) was attained at age 3 while the minimum culm density of age 2 (755.22Kg/m3) is slightly above the minimum wood density requirement of pulp industry. No significant variations existed in the extractive content, fuel properties, fibre dimensions and the derived values among ages. However, significant variation existed in porosity, density, holocellulose, α – cellulose, hemicelluloses and lignin content among ages. The silica content and all the mechanical properties varied significantly among ages except compression strength perpendicular to grain. By considering the basic characteristics of Bambusa vulgaris at different ages, the recommended optimum technical rotation age for cellulosic fibre production is 2 years, for structural application age 3 - 4 is considered the harvesting age as the density and strength start decreasing after age 3 except MOE while culms may be harvested for fuelwood at any age as it is not necessary to use matured culm.

Keywords: Optimal growth rotation, *Bambusa vulgaris*, fibre morphology, calorific value, chemical content, strength Properties

INTRODUCTION

One of the fundamental questions in forest economics is when the best time to harvest a forest stand is. Forest rotation or optimal rotation age represents the number of years which have passed between the establishment of a stand and its final harvesting at the end of regeneration period. The harvesting or rotation age of a plantation depends mainly on the growth rate of the species and the intended uses. According to Rezende *et al.* (2005), different methods are available to determine the optimal rotation age of a forest but the most common criteria for determining the optimal forest rotation adopted in forestry is the rotation when stand achieves maximum sustained yield or maximum mean annual increment (Nautiyal, 1988). As regards technical rotation, the focus is to harvest when the forest had yielded the most material for special use such as pulp and paper, structural material, fire wood, composite materials, etc. Technical rotation of forest stand is achieved when the stand produces the best properties in terms of quality of the stocks.

Bamboo is the most important Non Timber Forest Species suitable for diverse applications. Because of its strength, straightness and lightness combined with extraordinary hardness, size range, abundance, easy propagation and rapid growth, bamboo is suitable for an almost endless variety of purposes (Espiloy *et al.*, 1999). The appropriate use of any material depends on its properties to a large extent (Kamruzzaman *et al.*, 2008). For many purposes for which bamboo is used, optimum quality of the material is governed by its properties. As with wood, the properties and uses of bamboos are influenced by structural changes related to aging (Liese and Weiner 1996; Li *et al.*, 2007). According to Banik and Islam (2005), bamboo culms reach maturity between 3 and 4 years after cultivating and bamboo culms from 3.5 years of age were suitable for any utilization (Wang *et al.*, 2011). Harvesting bamboo culms at the right age and maturity is of great importance for the optimum quality suitable for several end uses. Most of the physical and mechanical properties of bamboo material change with increasing culm age (Liese, 1992; 1995; 1998; Liese and Weiner, 1996; 1997; Hidalgo, 2003). As with wood, there is variation in the technical quality of bamboo within and among species as well as between culms of different age classes within a species and within the different portions of the same culm.

For proper management of bamboo stand, matured culms should be harvested at the proper time to keep bamboo stands healthy and to promote the growth of new shoots. Properties of bamboo such as anatomical, physical and mechanical properties have been reported to be affected by age (Anonymous 2001, Kamruzzaman et al. 2008, Azmy *et al.*, 2011). Therefore, information on the properties of bamboo at different ages is required for appropriate end-use. As the newly produced culms undergo developmental changes of maturation with age, their quality and properties keep on changing until they get more or less stabilized. An understanding of variations in culm properties with age is essential not only to determine the appropriate age of optimum properties desired by the industry but also to predict the effects of reducing or increasing rotation on bamboo quality. The objective of this study was to determine the optimal technical rotation length for the best technical value of natural stands of *Bambusa vulgaris* based on the evaluated technical properties.

MATERIALS AND METHOD

The Bamboo species for this study *Bambusa vulgaris* was obtained from bamboo grooves on the Federal University of Technology, Akure Campus. Federal University of Technology, Akure lies between longitude 50 8'East and 50 10' East of the Greenwich Meridian and between latitude 70 16' North and 70 19' North of the Equator. Culms of age 2, 3 and 4 years were harvested. Three (3) representative culms from each age group were harvested making a total of nine (9) culms. The culms were carefully marked and labelled for easy identification according to ages. After this, experimental samples were prepared from the culms. The samples for proximate and chemical properties analysis were milled in their fresh state to pass BS 40 – mesh sieve (425um) but retained on BS 60 – mesh (250um sieve). After that, they were shade dried till attained constant moisture content while the samples for the physical and strength properties were prepared following standard procedures.

PROPERTY DETERMINATION

Bamboo density was determined following ASTM D 2395-93 (ASTM, 1993), Porosity according to ASTM D 2395-93 (ASTM, 1993). Shrinkage and swelling percentages according to ASTM D 143-94 (ASTM, 1994). Morphology of the bamboo fibres were determined following ASTM D 1030-95 (ASTM, 2007) and ASTM D 1413-61 (ASTM, 2007). Derived values were determined from the morphology of the fibres (Cell wall thickness = Fibre diameter – Lumen width/2; Slenderness ratio = Fibre length/Fibre diameter; Fibre flexibility = Lumen diameter/Fibre diameter; Runkel ratio = Cell wall thickness/ Lumen diameter x 2; Fibre rigidity = Cell wall thickness/Fibre diameter x 2; Luce's Shape factor as Fibre diameter^2 - Lumen diameter^2 / Fibre diameter^2 + Lumen diameter^2. Volatile matter was determined according to ASTM D3175-11 (ASTM, 2008). The percentage ash content was also determined according to TAPPI standard T211om-93 (TAPPI, 1993). The gross calorific value of the samples of biomass materials was determined in accordance with ASTM Standard E711-87 (ASTM, 2012). The fuel value index was determined by difference of calorific value and density and then divided by the ash content. Alcohol-benzene solubility according to TAPPI standard T 204 cm- 97 (TAPPI, 1997). Hot and cold water solubility according to TAPPI standard T 207 cm – 99 (TAPPI, 1999). N/10-NaOH Solubility according to TAPPI standard T 212 om – 02 (TAPPI, 2002). Holocellulose content according to TAPPI standard T 249 cm -85 (TAPPI, 1985). Alpha (α) cellulose content according to TAPPI standard T 203 cm – 99 (TAPPI, 1999). Hemicelluloses content was by difference of Holocellulose and Cellulose content. Klason Ligin Content according to TAPPI Standard T222 cm-06 method (TAPPI, 2006). The Silica content according to TAPPI Standard method T245 cm-07 (TAPPI, 2007). Both the compression strength parallel and perpendicular to grain were performed following ASTM standard D1037-94 (ASTM, 1994) while the flexural strength test were carried out following ASTM D 3043-95 (ASTM, 1995) with but with some modifications owing to the varying nature of the bamboo thickness. Three observations were recorded for each samples tested.
Effect of age on the bamboo properties were evaluated by analysis of variance at $p \leq 0.05$. Duncan Multiple Range Test was used to compare mean values for the different ages. Correlation analysis was used to determine the relationship between the age and the properties of bamboo

RESULTS AND DISCUSSION

Changes in Culm Physcial characteristics with age

The result of the culm density, porosity, shrinkage and swelling of *B. vulgaris* is presented on Tables 1 and 2. As with wood, density is one of the most useful parameters of measuring the quality bamboo (Zobel and Talbert 1984). It can also be used as a predictor of yield and quality of pulp and paper products (Dadswell and Wardrop 1959; Barefoot *et al.*, 1970). *B. vulgaris* density increased from age 2 to 3 and decline at age 4, porosity decreased from age 2 to 3 but later increased at age 4. There were significant variation in density and porosity among ages. Porosity of *B. vulgaris* has an advantage in preservative treatment to impart durability against biodeterioration. The density increased from age 2 to 3 and then decreases slightly at age 4. This may be due to the maturation of bamboo which usually start from early stage to the first 2 to 3 years with no further increament in properties as age advanced (Abd Latif *et al*., 1996) and also increase in the fibre and parenchyma cell wall thickness from younger bamboo to older bamboo (Razak *et al*., 2010; Razak *et al*., 2007; Alvin and Murphy, 1988). In addition, starch deposition and the lignification process that occurred in bamboo culms which also increases with age (Razak *et al*., 2010). The variation in the density of *B. vulgaris* is similar to the findings of Espiloy (1987), Liese (1986), Santhoshkumar and Bhat (2014).

Table 1: Influence of age on the Density and porosity *of B. vulgaris*

Age (Years)	Density (kg/m^3)	Porosity (%)
2	755.22^{c}	42.60^{a}
3	877.23^{a}	29.44^{c}
4	782.21^{ab}	36.86^{ab}

Means with the same letter vertically are not significantly different at ($p \leq 0.05$)

Table 2: Influence of age on the shrinkage properties *of B. vulgaris*

Source of Variation	Level	Longitudinal shrinkage (%)	Radial shrinkage (%)	Tangential shrinkage (%)	Volumetric shrinkage (%)
Shrinkage (%)	2	0.88^{a}	7.69^{a}	15.17^{a}	22.24^{a}
	3	0.94^{a}	5.21^{c}	8.80^{b}	14.34^{b}
	4	0.90^{a}	5.60^{ab}	10.72^{b}	16.50^{b}
Swelling (%)	2	0.46^{a}	6.17^{a}	8.88^{a}	27.36^{a}
	3	0.42^{a}	6.24^{a}	8.83^{a}	22.10^{a}
	4	0.68^{a}	4.64^{a}	9.19^{a}	30.53^{a}

Means with the same letter vertically are not significantly different at ($p \leq 0.05$)

Razak *et al*. (2007) and Alvin and Murphy (1988) got similar findings for *Gigantochloa scortechinii* and *Sinobamboo tootsik*. All these processes contributed significantly to the increase in density of older bamboo. Since there was significant difference in the density of *B. vulgaris,* from age 3 onwards, the density declined, therefore, age 3 is considered the rotation age for utilization as structural material, pulp and paper production, bio-composite materials production. Longitudinal shrinkage increased from age 2 to age 3 and later decreased at age 4 while radial, tangential and volumetric shrinkages decreased from age 2 to 3 and later increased at age 4. This trend is similar to observation of Wahab *et al*. (2012). The range of radial (4.54 – 8.70 %) tangential (5.42 % – 18.34 %) and volumetic shrinkage (10.48 % - 25.83 %) of *B. vulgaris* under study is similar to what was reported for *G. scortechinii* for radial (8.72 %) tangential (11.74 %) and volumetic shrinkage (16.83 %). *G. brang* radial (6.29 %), tangential (10.71 %) and volumetic shrinkage (10.72 %), *G. wrayi* for radial (6.68 %) tangential (9.68 %) and volumetic shrinkage (12.59 %) and *G. levis* for radial (5.57 %) tangential (7.52 %) and volumetic shrinkage (11.08 %) (Wahab *et al*., 2012). There were significant variation in the radial, tangential and volumetirc shrinkage of *B. vulgaris* among the three ages but that of longitudinal shrinkage was not different. The mean longitudinal, radial, tangential and volumetirc swelling of *B. vulgaris* varies from 0.24 % - 0.87 %, 3.00 % - 7.71 %, 6.20 % - 11.20 % and 9.52 % - 44.22 % respectively. Contrary to the result of the shrinkage properties, all the swelling properties showed no significant variation among ages, the swelling of both old and young bamboo were similar (Table 2). The swelling result is consistent with the dimensional stability of other bamboo species such as *Dendrocalamus strictus* (Ahmad and Kamke, 2000) and *Bambusa blumeana* (Toralde *et al*., 2013).

Changes in fiber morphology with age

The age of the culm influenced the overall quality of *B. vulgaris* for fuelwood, pulp and paper or biochemical applications. The results indicated that 3 years old *B. vulgaris* had longer fibre than age 2 and 4, this shows that the fibre of naturally-grown *B. vulgaris* complete their growth in 3 years which is slightly different from the findings of Wang *et al.* (2011) that reported longest fibre for 1 or 2 year old bamboo. Age 3 will have best pulp quality than those of age 2 and 4 based on fibre properties, although DMR Test shows no significant variation in the fibre length. The fibre length of *B. vulgaris* from the 3 age classes are very close to that of softwood tracheids, therefore, they can be used as an alternative raw material for pulp and paper. Generally, the fibre characteristics did not vary with age of the culm, therefore, culms from any of the ages may be considered for pulp and paper or fibre-based composites production with acceptable physical and mechanical properties since fibre length is positively correlated to strength properties. The insignificant variation in fibre lumen diameter among ages was also observed for *B. blumeana* and *G. scortechinii* (Abd. Latif and Tamizi, 1992). All the fibre characteristics increased from age 2 to 3 and decline at age 4 except the fibre diameter. RR, LSF and RC increased from age 2 to 3 and decline at 4. SR and FC decreased from age 2 to 3 and later increased at 4 years while only SF increased from age 2 to 4 years. DMRT showed no significant variation in all the fibre morphology and all the derived values among the 3 age classes. Fibre length and diameter was observed to be longer and larger in older bamboo compared with younger bamboo (Panshin and de Zeeuw 1970; Zobel and van Buijtenan 1989; Bowyer *et al*., 2003). *B. vulgaris* fibres from the 3 age classes have thin wall thickness, they all pass the RR < 1 (Xu et al., 2000), SR > 33 (Xu et al., 2000), FC > 0.55 (Bektas *et al.*, 1999) acceptable value for paper making fibre. LSF and SF falls in the range obtained for conventional materials for pulp and paper (Oluwadare and Sotannde, 2001; Ojo, 2003) and they also have low RC (0.2) which will enhance fibre bonding (Dutt and Tyagi, 2011). Since no significant variation existed in the fibre and derived morphological values among the 3 age classes, *B. vulgaris* fibres from any age are satisfactory for papermaking

Table 3: Influence of age on the fibre morphology and derived morphological values of *B. vulgaris*

	Age (Years)	Fibre length (mm)	Fibre diameter (µm)	Lumen width (µm)	Wall thickness (µm)		
Fibre morphology	2	2.03[a]	13.95[a]	12.19[a]	0.90[a]		
	3	2.15[a]	13.98[a]	12.66[a]	2.33[a]		
	4	2.11[a]	14.44[a]	12.41[a]	1.01[a]		
		RR	SR	FC	LSF	SF	RC
Derived indices	2	0.150[a]	144.10[a]	0.876[a]	0.134[a]	9.87×10^{-5} [a]	0.128[a]
	3	0.333[a]	140.80[a]	0.809[a]	0.216[a]	9.92×10^{-5} [a]	0.192[a]
	4	0.164[a]	145.5[a]	0.860[a]	0.150[a]	1.16×10^{-4} [a]	0.140[a]

Means with the same letter vertically are not significantly different at ($p \geq 0.05$)
Runkel ratio = RR; Slenderness ratio = SR; flexibility coeficient = FC; Luce shape factor = LSF; Solid factor = SF; Rigidity coeficient = RC

Changes in Fuel and Chemical characteristics with age

Tables 4 and 5 showed the variation in fuel and chemical composition of *B. vulgaris* with age. Ash and silica content increased with age from 2 to 4 years. FVI, CV and FC decreased from age 2 to 3 but increased at age 4 while only VM increased from age 2 to 3 and decline at 4. No significant variation existed in VM, FC, Ash, CV and FVI among ages. Only silica content differed significantly among ages (Table 4). Hot water and N/10 NaOH solubility, holocellulose and hemicelluloses increased from age 2 to 3 and decline at 4. Alcohol-benzene solubility increased from age 2 to 4 similar to the result of Li et al. (2007) and Wang et al. (2011), they both reported an increase of alcohol - toluene extractives with culm age. However, report of Hisham et al. (2006) showed no specific trend for alcohol - toluene extractives. Cold water solubility decreased from age 2 to 3 but increased from age 3 to 4 (Table 5). There were no significant variations in the extractive content among ages. Holocellulose and hemicelluloses increased from age 2 to 3 and decline at 4. α - Cellulose decreased from age 2 to 3 and later increased at 4 while lignin content decreased from age 2 to 4. No significant variation existed in all the fuel properties; the volatle matter, fixed carbon, silica content, ash content, calorific value and fuel value index as well as the cold water, hot water, alcohol-benzene and 10/N NaOH soluble extractives showed no significant variation only silica content showed significant variation among the 3 age classes.
The highest holocellulose content was found in age 3. Although there were no significant variation among the three age classes but the holocellulose content increased with age from age 2 to 3 and start decreasing at age 4. The silica and ash content increased with increasing culm age from 2 to 4 years (Table 4). This go contrary to that of Li et al. (2007), they recorded the highest ash and silica content in 1 year old culms of *F. yunnanensis*. High ash content is less desirable for fuel as it is non-combustible and hence reduces the heat of combustion (Dutt *et al*., 2008). *B. vulgaris* may be considered as good fuelwood and raw material for papermaking on account of comparatively low ash content (Bhatt and Tomar, 2002). α – Cellulose, Hemicelluloses and Acid insoluble lignin showed significant variation among the three age classes. Only Holocelluloses content was similar for all the ages (Table 5). Due to the lower lignin content, *B. vulgaris* will be easier to be delignified at lower alkali consumption with lower kappa number of pulp and hence lower requirement of bleaching chemical to achieve certain pulp brightness. The present result indicates that for the production of pulp and paper and biochemical application, technically, *B. vulgaris* can be harvested at 3 years rotation based on the highest holocellulose and hemicelluloses content or 4 years based on the lowest lignin content or 2 years based on the highest cellulose content or at any age for fuel wood and biochemical applications due to similar fuel properties and extractive content among ages.

Table 4: Influence of age on the fuel characteristics of *B. vulgaris*

	Properties					
Age (Years)	Volatile Matter (%)	Fixed Carbon (%)	Ash (%)	Silica content (%)	Calorific Value	Fuel Value Index
2	93.77[a]	4.69[a]	2.36[a]	1.19[a]	3075.00[a]	2153.00[a]
3	94.58[a]	3.96[a]	2.52[a]	1.37[a]	2954.90[a]	1209.80[a]
4	93.52[a]	4.17[a]	2.86[a]	1.98[b]	3443.30[a]	1993.40[a]

Means with the same letter vertically are not significantly different at ($p \geq 0.05$)

Table 5: Influence of age on the chemical characteristics of *B. vulgaris*

	Age (Years)	Properties			
		Cold Water	Hot Water	Alcoho-benzene	10/N Na0H
Extractive contents	2	5.21[a]	9.03[a]	5.30[a]	41.35[a]
	3	3.83[a]	9.28[a]	5.47[a]	42.76[a]
	4	4.27[a]	7.89[a]	5.90[a]	40.97[a]
		Holocellulose	α – Cellulose	Hemicelluloses	Lignin
Chemical contents	2	79.81[a]	75.68[a]	4.13[b]	45.90[a]
	3	80.62[a]	67.07[b]	13.55[a]	36.40[ab]
	4	79.01[a]	67.62[b]	11.41[a]	29.24[b]

Means with the same letter vertically are not significantly different at ($p \geq 0.05$)

Changes in the strength characteristics with age

Maturity of culm is a prerequisite for the optimum utilisation of bamboo in construction and other structural uses. The compressive strength perpendicular to grain and modulus of rupture (MOR) decreased from age 2 to 3 and later increased at age 4 while compressive strength parallel to grain and modulus of elsaticity (MOE) increased form age 2 to age 4 (Table 6). There were significant variability in the compressive strength perpendicular to grain, MOE and MOR while only compressive strength parallel to grain showed no significant variation among the 3 age classes. Generally, the strength properties seemed to be highest at age 4. The result further showed that all the strength properties do not differ between age 2 and 3 but those of age 2 and 3 were significantly lower than that of age 4 (Table 6). This result is in line with the report of Tommy *et al*. (2004), Rafidah *et al*. (2010) and Li (2004). The high strength properties of age 4 may be attributed to increase cellulose content and decreasing micro-fibril angle as well as higher content of vascular bundles which account for the higher density of bamboo and hence increase modulus strength (Sattar, 1990; Tommy *et al.*, 2004; Rafidah *et al*., 2010 and Li, 2004). Therefore, *B. vulgaris* from age 4 is suggested to be suitable for structural application or fibre-based composites products such as medium density fibreboard, hardboard, oriental strandboard, particle board etc. with better physical and mechanical properties.

Table 6: Influence of age on the Mechanical Properties of *B. vulgaris*

Age (Years)	Properties			
	Compression Perpendicular to grain (N/mm^2)	Compression Parallel to Grain (N/mm^2)	MOR (N/mm^2)	MOE (N/mm^2)
2	1096.40[a]	2240.80[a]	176.22[a]	19016[a]
3	901.45[a]	2251.90[a]	164.30[a]	19312[a]
4	1335.10[b]	2589.40[a]	208.00[b]	21617[b]

Means with the same letter vertically are not significantly different at ($p \leq 0.05$)

CONCLUSION

All the properties of *B. vulgaris* varied significantly among the three age classes except swelling, fuel, extractives and fibre morphology. The findings of the work, the earliest time of harvest for maximum technical value was 2 years for pulp and paper production due to its high cellulose content, for structural application and engineered material production, *B. vulgaris* from age 4 proved to be most suitable owing to the highest strength properties of this age class while any age may be harvested for extractives and fuelwood since no significant variation existed in the fuel properties and extractive content.

REFERENCES

Abd. Latif, M. and Mohd Tamizi, M. (1992): Variation in anatomical properties of three Malaysian bamboos from natural stands. *Journal of Tropical Forest Science* 5(1): 90-96.

Abd. Latif, M., Arshad, O., Jamaludin, K. and Mohd. Hamami, S. (1996): Chemical constituents and physical properties of B*ambusa heterostachya. Thailand Journal of Forestry* 15: 14–25.

Ahmad M. and Kamke F.A. (2005): Analysis of Calcutta bamboo for structural composite materials: physical and mechanical properties. *Wood Science and Technology*, 39, pp. 448-459.

Alvin, K.L. and Murphy, R.J. (1988): Variation in fibre and parenchyma wall thickness in culms of the bamboo *Sinobambusa tootsik*. *International Association of Wood Anatomist (IAWA) Bulletin* 9: 353-361.

American Society of Testing Materials (ASTM) (1997): Standard test methods for specific gravity of wood and wood-based materials. Annual Book of ASTM Standards Des. D 2395-93 (Reapproved 1997) Vol –4.10. Philadelphia, PA.

American Society of Testing Materials ASTM D 143-94 (ASTMD, 1997): Standard Method of Testing Small Clear Speciemens of Timber. Annual Book of ASTM Standard Des. ASTM D143-94 (Reapproved, 1997) Vol 4.10. Philadelphia, PA

American Society for Testing Materials (ASTM) (1995): Standard Test Methods for Testing Structural Panels in Flexure, Annual Book of ASTM Standards, ASTM D 3043 – 95, Vol. 04.10, pp 425 – 435.

American Society of Testing Materials (ASTM) (1997): Standard test methods for evaluating properties of wood-based fiber and particle panel materials. Annual Book of ASTM Standards Des. D 1037-96a. Vol –4.10. Philadelphia, PA.

American Society for Testing and Materials (ASTM) (2007): Preparation of decayed wood for microscopicalexamination. ASTM D 1413-61

ASTM International (2008): ASTM D3175-11, Standard Test Method for Volatile Matter in the Analysis Sample of Coal and Coke. Annual Book of ASTM Standards, 153-154.

ASTM International (2012) ASTM Standard E711-87, Standard Test Method for Gross Calorific Value of Refuse-Derived Fuel by the Bomb Calorimeter. http://ia600806.us.archive.org/23/items/gov.law.astm.e711.1987/astm

Anonymous. (2001): Cultivation and Integrated Utilization on Bamboo in China. China National Bamboo Research Centre, Hangzhou.

Azmy M, Sulaiman O, Razak W and Rokiah H. (2011): Physical characteristics and weight relationship of *Gigantochlo scortechinii* (buluh semantan) in 1-, 2- and 3-year- old natural stand bamboos. *Pertanika Journal of Agricultural Science* 34: 25–32.

Bektas I., Tutus, A. and Eroglu H. (1999): A study of the suitability of Calabrian pine (*Pinus brutiaten*) for pulp and paper manufacture, *Turkey Journal of Agriculture and Forestry* 23: 589-599

Bhatt B.P. and Tomar J.M.S. (2002): Firewood properties of some indian mountain tree and shrubs species, *Biomass and Bioenergy*, 23, 257-260

Bowyer JL, Shmulsky R and Haygreen JG. (2003): Forest products and wood science: An introduction. Fourth edition. Iowa State University Press, Iowa.

Dutt D., Upadhyaya J.S., Singh B. and Tyagi C.H. (2009): Studies on *Hibiscus cannabinus* and Hibiscus sabdariffa as an alternative pulp blend for softwood: an optimisation of kraft delignification process. *Industrial Crops and Products* 29: 16-26.

Dutt D. and Tyagi C.H (2011): Comparison of various Eucalyptus species for their morphological, chemical, pulp and paper making characteristics. *Indian J. of Chemical Tech*. Vol 18, PP 145-151

Espiloy ZB. (1987): Mechanical properties and anatomical relationship of some Philippines bamboos. Pp 257–265 in Rao AN, Dhanarajan G & Sastry CB (eds) International Workshop on Bamboo. 6–14 October 1985, Hangzhou.

Hidalgo-Lopez, O. (2003). Bamboo: The Gift of Gods. Oscar Hidalgo, Colombia

Hisham N. H, Othman S, Rokiah H, Abd Latif M, Ani S & Mohd Tamizi M. (2006): Characterisation of bamboo *Gigantochloa scortechinii* at different ages. *Journal of Tropical Forest Science* 18: 236–242.

Kamruzzaman M, S aha SK, Bose AK and I slam MN. (2008): Effects of age and height on physical and mechanical properties of bamboo. J*ournal of Tropical Forest Science* 20: 211–217.

Li, X. (2004): Physical, chemical and mechanical properties of bamboo and its utilization potential for fiberboard manufacturing. A Thesis: The School of Renewable Natural Resources. Louisiana State University of Agriculture Centq Baton Rouge, La 70803, USA.68p.

Li, X.B., T.F. Shape, G.F. Peter, C.Y. Hse and T.L. Eberhardt, (2007): Chemical changes with maturation of the bamboo species *Phyllostachys pubescens*. *J. Trop. Forest Sci*., 19(1): 6-12.

Liese, W. (1986): Characterization and utilization of bamboo. In Higuchi, T. ed., 1986. Bamboo production and utilization. Proceedings of the Congress Group 5.04, production and utilization of bamboo and related species, XVIII IUFRO World Congress Ljubljana, Yugoslavia, 7-21 September 1986. Kyoto University, Kyoto, Japan.

Liese, W.(1992). The structure of bamboo in relation to its properties and utilisation. in Zhu, S., Li, W. Zhang, X. and Wang, Z. (eds.) Bamboo and Its Use. Proc. Internat. Symp. on Industrial Use of Bamboo , Beijing, China, 7- 11 Dec. 1992. ITTO, Japan, and Chinese Acad. For., Beijing,China. pp. 95- 100.

Liese, W. (1995).Anatomy and utilisation of bamboo. Eur. Bamboo Soc. J., Belgium 1:5-12.

Liese, W. and Weiner, G. (1996). Ageing of bamboo culms. A review. Wood Sci. Technol. 30: 77-89.

Liese, W. and Weiner, G. (1997). Modification of bamboo culm structures due to ageing and wounding. In Chapman, G. (ed.) The Bamboos. Linnaean Society. London, UK. pp. 313- 322.

Liese, W. (1998). The Anatomy of Bamboo Culms. INBAR, Beijing, China, 204pp
Nautiyal, J.C. (1988): Forest Economics. Principles and Applications. Canadian Scholars' Press Inc. Toronto, p 581
Ojo D.O (2013): Determination of Pulp and paper making suitability indices of some Nigerian species of Leguminosae: Caesalpinoides. *Academic Journal of Interdisciplinary Studies*. 2(13): 61-68
Panshin, A.J. & de Zeeuw, C. (1970): Textbook of wood technology. New York, McGraw Hill Book. Co. 1:237-258.
Rafidah S., Zaidon A., Hashim W. S., Razak W. and Hanim A. (2010): Effect of heat oil treatment on physical properties of Semantan bamboo (*Gigantochloa scortechinii* Gamble). *Journal of Modern Applied Science*. ISSN 1812-5654. Asian Network for Scientific Information. 4(2): 107-113.
Razak, W., Janshah, M., Hashim, W.S and Shirley, B. (2007): Morphological and anatomical characteristics of managed natural bamboo stands *Gigantochloa scortechinii*. *Journal of Bamboo and Rattan*, 6(2), 115-122.
Razak W., Mohd Tamizi M., Othman S., Aminuddin M. , Affendy H and Izyan K.(2010): Anatomical and Physical Properties of Cultivated Two- and Four-year-old *Bambusa vulgaris Sains Malaysiana* 39(4)(2010): 571–579
Rezende, J. L. P. de; Oliveira, A. D. de; Rodrigues, C. (2005): Efeito dos tributos no custo de produção, na rotação e na reforma de Eucalyptus spp. Cerne, Lavras, v. 11, n. 1, p. 70- 83, jan./mar.
Sattar M.A, Khabir MF & Bhattacharjee DK. (1990): Effect of age and height of muli (*Melocanna baccifera*) and borak (*Bambusa balcooa*) bamboos on their physical and mechanical properties. *Bangladesh Journal of Forest Science* 19: 29–37.
Santhoshkumar R and Bhat K.V (2014): Variation in density and its relation to anatomical properties in bamboo culms, *Bambusa bambos* (L.) Voss. *Journal of Plant Sciences*. 2014 2(3): 108 – 112
TAPPI T211 om-93. (1993). "Ash in wood, pulp, paper and paperboard: Combustion at 525°C," TAPPI Press, Atlanta, GA.
TAPPI (Technical Association of the Pulp and Paper Industry). (1997). Solvent extractives of wood and pulp -T204cm, 97:1-5.
TAPPI (Technical Association of the Pulp and Paper Industry). (2006). Acid-insoluble lignin in wood and pulp. TAPPI, Atlanta USA. T222 cm, 06: 1-6
TAPPI. (1985). "Carbohydrate composition of extractive-free wood and wood pulp by gas-liquid chromatography," TAPPI Method T 249 cm-85, TAPPI Press, Atlanta, Georgia.
TAPPI (Technical Association of the Pulp and Paper Industry). (1999). Water solubility of wood and pulp- T207cm, TAPPI, Atlanta USA. 99: 1-3.
TAPPI (Technical Association of the Pulp and Paper Industry). (2002). One percent sodium hydroxide solubility of wood and pulp- T212cm, 02: 1-5.
TAPPI (Technical Association of the Pulp and Paper Industry) (1999): Alpha-, beta- and gamma-cellulose in pulp T 203 cm-99. TAPPI Standard Test Method.
TAPPI (Technical Association of the Pulp and Paper Industry) (2007): Silicates and silica in pulp (wet ash method) T 245 cm-07. TAPPI Standard Test Method
Tommy, Y., Lo, H.Z., and Cui, H.C. (2004): The Effect of fibre on strength capacity of bamboo. *Materials and Letters*, 58(21), 2595-2598
Wahab R, O., Lokmal, N., and Hassan, M. G. (2012). "Culms and above-ground biomass assessment of *Gigantochloa scortechinii* in response to harvesting techniques applied," *Journal of Agrobiotechnology* 3(1), 23-33.
Xu, Y.L., Y. Zhang, and W. Wang. (2000): Study on manufacturing technology ofmedium density fiberboard from bamboo. Sym. on Uti. of Agri. and For. Res. Proceedings. pp. 117-123.
Zobel, B. and Talbert, J. (1984): Applied Forest Tree Iniprovement. John Wiley & Sons, New York.
Zobel, B.J. and J.P. Van Buijtenen, (1989): Wood variation: Its causes and control. Springer-Verlag, Berlin, Heidelberg, pp: 363.

Comparative Study of the Medicinal and Nutritional Constituents of Honey from Plateau State and Rivers State in Nigeria

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ABSTRACT

Honey is a complex product due to its properties and composition which depend not only on the nectar-providing plant species, but also on other factors such as bee species, geographic area, season, mode of storage, harvest technology and conditions. This research aimed at examining and comparing the medicinal and nutritive values of honey from two states located in different vegetation zones of Nigeria. Honey samples were collected from two apiaries in Plateau (Northern Guinea savanna) and Rivers States (Mangrove swamp forest). The dominant flora surrounding each apiary was collected, extracted and subjected to phytochemical analysis to ascertain plants being utilized by the honeybees. All samples were collected and analyzed by standard method provided by Prajapiti, 2007. Results showed the phytochemical constituents present in the honey and flora sample. They were steroids, tannins, carbohydrate and cardiac glycosides; flavonoid was present in all flora samples from Plateau State but negative in its honey, which connotes that bees sometimes utilize plant species that are far away from their immediate environment. The results obtained also showed that there was significant difference ($P < 0.01$) in the nutritional constituent of honey from the study sites. It was observed that moisture content, crude protein, crude fat and ash were higher in Rivers state while crude fibre, Nitrogen Free Extract (NFE) and calcium were higher in Plateau State. The values for moisture content and crude fat (20.63% ± 0.34 and 2.18 ± 0.18, respectively) were high in Rivers State. Honey with high moisture content easily ferments and high fat content makes foods susceptible to rancid spoilage during storage. Honey from the two study sites is rich in nutritional and medicinal elements. However, honey from Plateau state had vital elements in higher concentration with a longer storage capacity than Rivers state.

Keywords: Honey, medicinal constituents, flora, vegetation zones, nutritional value

INTRODUCTION

Honey is a sweet substance produced by bees from the nectar of blossom or from secretions of living part of plants which they collect, transform and combine with specific substances and store in honeycombs (Codex Alimentarius Commission, 2001). It is a concentrated aqueous solution of inverted sugar that contains a mixture of other carbohydrates, amino and organic acids, minerals, aromatic substances, pigments, waxes and pollen grains to make it complex (Rashed and Soltan, 2004). Many studies have demonstrated that honey serves as a source of natural antioxidants, which are effective in reducing the risk of heart disease, cancer, immune system deficiency, cataracts, different inflammatory processes (National Honey Board, 2002). In recent years, the antibiotic and wound healing properties of honey have been scientifically proven (Molan and Betts, 2004).

Honey can be classified according to the following parameters; first through its source which takes care of the flora origin such as the nectar from which it is derived. The honey may be from a specific dominating plant (mono floral) or mixture of plant (multi floral) depending on the nature of the vegetation in the foraging area of the colony (Ojeleye, 1999). Secondly its season which is the time of the year honey is being harvested and its location. For instance, honey harvested immediately after heavy rainfall or in the early period of harvesting season can be characterized as “early honey” due to its low viscosity (Ojeleye, 1999). Lastly its composition which varies in plant species composition and nature of soils on which the plants grow. Since the demand for honey to solve various deficiencies and ailments is growing higher on a daily basis, ascertaining the quality and quantity of honey found in some selected vegetation zones is paramount and hence, the research was conducted.

METHODOLOGY

Study Area

This study was conducted in both Jos North Local Government Area (L.G.A) of Plateau state and Etche Local Government Area (L.G.A) of River state. Jos metropolis is located in Northern Guinea Savanna while Etche L.G.A of Rivers state is situated in the Southern part of Nigeria consisting mangrove forest line.

Procedure

Freshly harvested honey was collected with the dominant flowering plant from the study locations (Rivers and Plateau states). The apiaries were laid out in a Randomized Complete Block Design (RCBD). At each location, samples were collected from two (2) beehives with two (2) replicates in each beehive. Samples were labeled in containers and kept under room temperature. Test for the phytochemical constituents present was conducted in pharmacology laboratory of University of Jos, while test for the nutritional constituents was conducted at biochemical laboratory of National Veterinary Research Institute, Vom. Analysis of Variance (ANOVA) was used to analyzed the data. The phytochemical screening of the samples (honey and flora) was screened for their constituents by standard method provided by Prajapati (2007).

RESULTS

Table 1: The Phytochemical Constituents of Honey from the Study Area

	Rivers State				**Plateau State**			
Constituents	A1	A2	B1	B2	C1	C2	D1	D2
Alkaloids	-	-	-	-	-	-	-	-
Steriods	+	+	+	+	+	+	+	+
Anthraquinone	-	-	-	-	-	-	-	-
Flavonoids	++	+	+	+	-	+	+	++
Tannins	+	+	+	+	+	+	+	+
Saponins	-	-	-	-	-	-	-	-
Carbohydrates	+++	+++	+++	+++	+++	+++	+++	+++
Cardiac glycosides	+++	++	++	+++	+++	+	++	+

Keys

_	Negative	A	Finima, Rivers
+	Present	B	Dema, Rivers
++	More Present	C	FCF, Plateau
+++	Highly Present	D	PADP, Plateau

Table 2: The Phytochemical Constituents of the Flora Samples from the Study Area

Constituents	**Rivers State** **A**	**B**	**Plateau State** **C**	**D**
Alkaloids	-	-	-	-
Steriods	+	+	+	++
Anthraquinone	-	-	-	_
Flavonoids	++	++	+++	+++
Tannins	++	++	+++	++
Saponins	-	-	+	+
Carbohydrates	++	++	+++	+++
Cardiac glycosides	+	-	-	+

Keys

A1, A2 -Hives in Apiary one; B1, B2-Hives in Apiary two (Rivers state)

C1, C2-Hives in Apiary one; D1, D2 -Hives in Apiary two (Plateau state)

Table 3: Nutritional Analysis on Honey Constituents from the Study Sites

	Treatments	Mean	Std. Deviation	Std. Error Mean
Moisture	Rivers State	20.63	0.69	0.34
	Plateau State	14.31	2.04	1.02
Crude Protein	Rivers State	1.13	0.06	0.03
	Plateau State	0.88	0.26	0.13
Crude Fiber	Rivers State	1.34	0.48	0.24
	Plateau State	1.81	0.40	0.20
Crude Fat	Rivers State	2.18	0.36	0.18
	Plateau State	0.76	0.38	0.19
Ash	Rivers State	0.31	0.20	0.10
	Plateau State	0.18	0.09	0.04
NFE	Rivers State	74.47	0.76	0.38
	Plateau State	82.05	2.45	1.23
Calcium	Rivers State	0.19	0.03	0.02
	Plateau State	0.21	0.09	0.04
Phosphorous	Rivers State	0.06	0.01	0.00
	Plateau State	0.06	0.01	0.00

Table 4: T-test of the Nutritional Analysis from the Study Sites

	T-test for Equality of Means								
	F	Sig.	T	Df	Sig. (2-tailed)	Mean Diff	SE Diff	95% CI of the Diff	
								Lower	Upper
Moisture	29.15	0.00	5.86	6	0.001*	6.32	1.08	3.68	8.96
Crude Protein	2.52	0.16	1.85	6	0.114ns	0.25	0.14	-0.08	0.58
Crude Fiber	1.42	0.28	-1.51	6	0.181ns	-0.47	0.31	-1.24	0.29
CFa	0.07	0.80	5.43	6	0.002*	1.42	0.26	0.78	2.05
Ash	55.50	0.00	1.29	6	0.245ns	0.14	0.11	-0.12	0.40
NFE	33.41	0.00	-5.91	6	0.001*	-7.58	1.28	-10.71	-4.44
Calcium	2.26	0.18	-0.44	6	0.677ns	-0.02	0.05	-0.13	0.09
Phosphorous	0.00	1.00	1.41	6	0.207ns	0.01	0.00	-0.00	0.01

* Significant difference
NS No significant difference
CFa Crude Fiber
NFE Nitrogen Free Extract

DISCUSSION

Table 1 showed the phytochemical constituents present in the honey samples. They were Steroids, Tannins, Carbohydrate and Cardiac glycosides while Alkaloids, Anthraquinones and Saponins were negative. Flavonoid was present in all samples except in

a replicate of honey sample from FCF Jos, although, there was no significant difference. Saponin was absent from the honey samples collected in Rivers state but positive in the flora samples collected from Plateau State, which suggests that the bees get their pollen from the dominant plants (flora) in the apiary but sometimes get pollen from other alternative plants which may be reason behind its absence in the honey samples but present in the dominant flora sample. Flavonoids, a class of antioxidants which are found in plants as phytochemicals, are present in nearly all plants derived foods and beverages. The concentration of flavonoids is largely influenced by genetic factors, plants species, environmental conditions, ripeness, processing and storage (Hughes, 2002). The presence of tannins in honey has led to the use of honey to treat variety of ailments through topical application. It has been used as remedy for burns, ulcers and wound healing, simply because of it soothing effect during its application to open wounds. Flavonoid is believed to contribute to anti-bacteria properties particularly in treatment of antibiotic resistant bacteria strains. (Cushine and Lamb, 2005). According to Ajibola (1995), the application of honey dressing was used on a patient after failure of healing from conventional treatment which includes radiation therapy. Cardiac glycosides help in the control of vascular health/diabetes. There is an evidence to suggest that micro components in honey have positive effect on makers of heart health. Al-Waili (2004) in his study compared ingestion of a fructose and glucose mixture with consumption of honey on various heart biomarkers. The study showed honey to have positive effects on numbers of biomakers of vascular health.

Results showed that amount of Moisture, Crude protein, Crude fat and Ash were higher in Rivers state while Crude fibre, Nitrogen Free Extract (NFE), Calcium were higher in Plateau State. Rivers state had a high moisture content of 20.63% while Plateau state was 14.31% (Table 3). Moisture content is practically the most important parameter that determines quality of honey, since it affects storage life and processing characteristic. The variations in the moisture content of honey have been attributed to the composition and floral origin of honey (Malika *et al*., 2005). The low moisture content of honey also forms an important part of the system which protects honey from being degraded by microorganisms as observed in samples from Jos East. Moisture content, Crude fat and NFE were significant (P= 0.001, P=0.002 and P=0.001, respectively). According to the United States Standards, extracted honey may not contain more than 18.6% moisture. Moisture level of about 17% has been found to be optimum. When honey is not hermetically sealed, because of its hygroscopic nature, it absorbs moisture. The moisture content of honey is one of the criteria that determines the shelf stability of honey (Azenedo, *et a*l., 2003). The value of moisture content which is highly significant depicts that honey obtained from Rivers state easily deteriorates while honey obtained from Plateau State stands a better chance in storage. High moisture content also affects the viscosity of the honey.

Ash content is a reflection of the total inorganic minerals that are present in a sample after incineration (Vanhanen, *et al*., 2011). The low ash values recorded fell within the range typical of natural nectar honeys (Nyau, *et al.*, 2013) and not of honeydew honeys, which have been reported to have high ash content (Viuda-Martos, *et al*., 2010). Crude fat value was also highly significant in honey obtained from Rivers state. High fat content makes foods to be susceptible to rancid spoilage during storage (Durrani, *et al*., 2011). The difference of Nitrogen free extract (NFE) in samples from Plateau State was higher and highly significant as compared to Rivers State. All other nutritive compositions such as Crude protein, Ash, Crude fibre, Calcium indicated no significant difference between the two states. The determined proximate composition of the honey employed for this study agrees with most similar studies that have evaluated the composition of honey (Molan, 1992; Dimitrova, *et al*., 2007). The results showed that these honey samples were quite rich in minerals. The percentage mineral content is considered as a quality criterion indicating the possible botanical origin of honey (Vanhanen, *et al*., 2011). Soluble dietary fibres have health-promoting properties as they have been implicated in lowering plasma and liver cholesterol concentration (Behall and Resier, 1986), diarrhoea treatment and detoxification of poisonous metals (Cohn and Cohn, 1996). Hence from the results, it can be deduced that there is a variation in the nutritive composition of the honey samples analysed. Honey from Plateau State had more nutritive components and could be stored over a longer period of time.

Conclusion and Recommendation

This research revealed that honeys possess some differences in their composition due to the differences in flora species in which the honey bees obtain pollen. Vegetation type and climatic factors of a region influence quality honey production. The results obtained showed that there is significant difference in nutritional constituents of honey from Rivers State as compared to Plateau state. Honey obtained from Plateau State had vital components in higher concentration which serves as medicines and has nutritional uses with a longer storage capacity.

It is recommended that this study should be carried out in other vegetation zones across the country and at both raining and dry season to ascertain the effect of season on the medicinal and nutritive composition of honey.

REFERENCES

Ajibola, A. A. (1995). Honey in the post-surgical wound management in goats. (DVM Dissertation) Nigeria. University of Ibadan, Nigeria.

Al-Waili, N.S, (2004). Natural honey lowers plasma glucose, C – reactive protein, homocysteine and blood lipids in healthy, diabetic and hyperlipidemic subjects: Comparism with dextrose and sucrose, *J. Med Foo:* 7: 100 – 107.

Azenedo, L., Azeredo, M., De Souza, S. and Dautra, L. (2003). Protein content and physiochemical properties in honey samples of *Apis Mellifera* of different floral origins. Food Chemistry. 80(2) 249 – 254.

Codex Alimentarius Commission (2001). Revised Codex Standard for honey, Codex STAN 12–1981.

Cushnie, T. and Lamb A. (2005) Antimicrobial activity of flavonoids, *Int J. Antimicrob agent* 26:343 – 356.

Dimitrova, B., Gevrenova, R. and Anklam, E. (2007).Analysis of phenolic acids in honeys of different floral origin by solid-phase extraction and high-performance liquid chromatography. *Journal of Phytochemical Analysis* 18(1): 24-32.

Molan, P.C. (1992).The Antibacterial Activity of Honey. The Nature of the Antibacterial Activity conference, *Bee World*, p5-28.

Nyau, V., Mwanza, P. & Moonga, B. (2013). Physicochemical qualities of honey harvested from different beehive types in Zambia. *African Journal of Food Agric. Nutrition and Development*, 13(2): 7415-7427.

Ojeleye, B. (1999). Foundation of Beekeeping in the tropics. CENRAD Press, Ibadan. Pp 43- 135.

Prajapati (2007) A handbook of medicinal plants. A complete source boo – India, Agroboos Publishers.

M.N. Rashed, M.N. and Soltan, M.E (2004). Major and trace elements in different types of Egyptian mono-floral and non-floral bee honeys. *J. Food Compos. Anal.*, 17, pp. 725–735

The National Honey Board. 2002. Honey – health and therapeutic qualities. Available from: http://www.honeystix.com/HoneyStix/compendium.pdf . *Accessed Jan 7, 2010.*

Tomas-Barberan, F. A., Martos, I., Ferres, F., Radovic, B. S., Anklam, E. (2001). HPLC flavonoid profiles as markers for the botanical origin of European unifloral honeys, *J Sci Food Agric* 81:485-496

Viuda-Martos, M., Ruiz-Navajas, Y., Zaldivar-Cruz, J., Kuri, V., Juana Fernandez-Lopez. J., Carbonell-Barrachina, A., Perez-Alvarez, J. (2010). Aroma profile and physicochemical properties of artisanal honey from Tabasco, Mexico. *International Journal of Food Science and Technology*, 45: 1111-1118.