SUSTAINABLE AGRICULTURE, NATURE CONSERVATION AND CLIMATE CHANGE RESPONSE

PROCEEDINGS OF THE 1ST FACULTY OF AGRICULTURE INTERNATIONAL CONFERENCE, NNAMDI AZIKIWE UNIVERSITY, AWKA, NIGERIA

held at the Nnamdi Azikiwe University, Awka Campus, Anambra State, Nigeria from 22nd to 24th of March, 2023.

Edited by:

Nkiru T. MELUDU,
Eucharia A. OBIDIEBUBE,
Onyekachi CHUKWU,
Chika F. IKEOGU.

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Nature Conservation for Sustainable Agriculture and Climate Change Response

Prof. Charles A. Igwe

Vice-Chancellor, University of Nigeria, Nsukka

on the Occasion of the 1st Faculty of Agriculture International Conference (Hybrid), Nnamdi Azikiwe University,Held at the University Auditorium, Awka Campus of the University from 23rd to 24th March 2023, on the First Day Being Thursday 23 March 2023

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PROTOCOL

Your Excellency, The Executive Governor of Anambra State,

Mr Chairman of this Opening Ceremony,

Hon. Commissioner for Agriculture, Anambra State,

Vice-Chancellor, Nnamdi Azikiwe University, Awka

Principal Officers of the University Present,

Dean, Faculty of Agriculture, Nnamdi Azikiwe University, Awka

Deans of Faculty and Directors of Institute of the University,

Heads of Department and Professors Present,

My Lords Spiritual and Temporal,

Special Invitees and Guest Lecturers,

Members of the University Community,

Chairman and Members of Conference Organizing Committee,

Gentlemen of the Press

I warmly welcome you all to this historic and very eventful occasion. On receiving the invitation to present a **keynote address** of this 1st Faculty of Agriculture International Conference inthis University, my originalintentwas to make this address a mere welcoming of all of us participants in less than 10 minutes and, if permitted, to formally declare the event open. To my surprise, however, the Conference Organizing Committee assigned a **keynote address 'topic'**to me, allotting a whooping duration of 40 minutes to me for this task. I am not familiar with this style of appending a topic to a keynote address, and the intention of the Committee in doing so is not quite clear to me. If their intention is to use the opportunity of an academic conference in a university environment to test my ambidexterity in discharging my duties in my valuednoble profession of Soil Science and Agriculture and in university administration cum management as the current Vice-Chancellor of the University of Nigeria (UNN), then I hope to pass the test. Whatever their intention is, however,I do not see myself being able to keep to my original intent, in that I may end up disappointing them and perhaps you the audience by 'hybridizing' this otherwise simple task into a mini '**academic' keynote address**. With this, I say 'welcome' to you all once again.

The theme of this conference***Sustainable Agriculture, Nature Conservation and Climate Change Response***is apt and very timely as many seem to have lost the understanding of the intricate interdependence between agriculture, natural environment and climate, and that a kind of functional balance or equilibrium among them isneedednot just to sustain life on earth, but also to improve the economy thereby improving the welfare of mankind and making this life more meaningful. Each of agriculture, natural environment and climate influences or modifies the other two over time. All forms of agricultural malpractice constitute harm to and hence degradation of the natural environment the impact to which the climate must ultimately respond. This 'change' in climate would come back to reflect in agricultural productivity, and the attempts to adjust degrade the natural environment the more, and the cycle goes on and on. This undesirable relationship among agriculture and food production, environmental degradation and climate change could, therefore,be said to depict a vicious cycle(Amalu 2005; Lal 2011).I have to briefly explore this relationship between agriculture, natural environment and climate because my **keynote address 'topic',** ***Nature Conservation for Sustainable Agriculture and Climate Change Response,***would appear to confine me to discussing how conservation of the natural environment makes for sustainable agriculture and mitigates climate change without looking at the reverse phenomenon.

Widespread anthropogenic-related environmental degradation and the exacerbating role of climate change in tropical Africa It is widely acknowledged by policy-makers and soil specialists that agricultural productivity of tropical Africa is lowest in the world, and that soil degradation in expanding at an alarming rate (FAO 2015). Permit me to press home the undesirable relationship among agriculture and food production, environmental degradation and climate change in tropical Africa using soil erosion as the most perversive form of environmental degradation and our southeastern Nigeria as a case study. Though soil erosion is a long-standing problem in this ecozone,land misuse/mismanagement is a major factor driving this menace. The erosion problem often becomes accelerated and advances or escalates to life-threatening gullies (**Figure 1**).

Figure 1: A gullied farmland in southeastern Nigeria. Source: Igwe (2011)

In responding to these changes in the environment, the climate not only changes, affecting Earth's temperature, precipitation and hydrological cycles. Climate change has fundamentally altered the water cycle around the world. The result is shifting precipitation and evapotranspirationpatterns. In some cases, it is more frequent severe rain events which often lead to flooding; in some others, it is increased evapotranspirationleading to more severe droughts. In many areas, therefore, rainfall has become either increasingly abundant or in desperately short supply, relative to long-time averages. And this is the way climate change affects water availability for agriculture and hence agricultural productivity. But that is not at all, because the change in rainfall pattern and characteristics (amount, intensity and distribution) has implications for the environment. Increases in rainfall intensity will pose serious erosion threat particularly in erosion-prone areas such as our southeastern Nigeria.This push-pull nexusshows that soil erosion induces climate change which in turns is a significant factor exacerbating the soil erosion crises in recent times.

Nature Conservation for Sustainable Agriculture?Nature conservation as a concept involves preserving ecological systems to the extent of coming as close as possible to their original states for maintenance of healthy environments. In the strict sense of this concept, there is no room for agriculture even at the highest levels of sustainable practices. This is because, as we all know, agriculture involves tampering with these ecological systems and hence the natural environment.As a profession that is primarily for food production, however, agriculture is inevitable for the survival of mankind. Sustainable agriculture is about judicious exploitation of natural resources and conservation of same.Conversely as it may seem, forestry promotes conservation of natural resources and judicious exploitation of same. Forestry is thus the profession that is closest to the concept of nature conservation. One could say that agriculture is to natural environments and their provisioning of ecosystem goods what forestry is to the same natural environments and their provisioning of ecosystem services. The inevitability and universality of agriculture has led to a situation whereby virtually all natural ecosystems are now **agroecosystems**. Also, the inevitability of agriculture and the indispensable roles of forestry in the survivability of mankind gave rise to the marriage between these two professions in the form of **agroforestry.**

If we now view realistic**nature conservation** as that which involvesthe 'inevitable' **agriculture**, let us look at how it contributes to making this agriculture **sustainable**before looking at the ensuing **response of climate change**. Without prejudice to the several definitions of agriculture that we are familiar with, Late Professor F.O.C. Ezedima defined agriculture simply as the use of **three *Fs***(farming, forestry and fishing) on land to produce **five *Fs***(food, feed, fibre, fuel and fun).

There have been dramatic increases in agricultural production since the end of World War II, thanks mostly to advances in technologies. But in the words of George B. Shaw, 'science is always wrong; it never solvesa problem without creating ten more'. Imagine the increases in greenhouse gases (GHGs) emissions and other forms of air pollution,increases in topsoil erosion, accumulation of heavy metals and toxic chemicals in the soil and water resources, plant and animal uptake of them enroute the food web, loss of biodiversity,groundwater contamination,etc.These changes in the atmosphere, lithosphere, biosphere and hydrosphere constitute new threats to biological systems,environmental safety andhuman health. This situation heightened during the **Green Revolution** of the 1960s which rested on the tripod stand of breakthroughs in biotechnology as applied to breeding for improved varieties, chemotechnology defined by increased use of agrochemicals mostly fertilizers but also herbicides and pesticides,and hydrotechnology in the form of surge in irrigation technology. The use of improved varieties often entails monocropping and hence loss of biodiversity and natural ecological balance. The adverse effects of agrochemicals in agriculture even when not abused are widely known. Irrigation often goes with a wide range of the so-called irrigation externalities including salt build-up, soil erosion and disease outbreak. These numerous adverse effects led to the realization of the importance of sustainability of agriculturalpractices.

The term "sustainable agriculture" was defined by the United States Department of Agriculture (USDA) in 1977 as an integrated system of plant and animal production practices having a site-specific application that will, over the long termsatisfy human needs; enhance environmental quality and the natural resource base supporting agriculture; use non-renewable and on-farm resources most efficiently;integrate, where appropriate, natural biological cycles and controls; sustain the economic viability of farm operations; and enhance the quality of life for all.

The call forsustainable agricultureis not entirely new if we recall the **Eleventh Commandment**proposed by Lowdermilk's (1953), Assistant Chief, Soil Conservation Service of USDA:

> Thou shalt inherit the Holy Earth as a faithful steward, conserving its resources and productivity from generation to generation.Thou shalt safeguard thy fields from soil erosion, thy living waters from drying up, thy forests from desolation, and protect thy hills from overgrazing by thy herds, that thy descendants may have abundance forever. If any shall fail in this stewardship of the Land thy fruitful fields shall become sterile stony ground and wasting gullies, and thy descendants shall decrease and live in poverty or perish from off the face of the earth.

Sustainability must cut across agroecosystems and the more encompassing food systems. For these systems to be sustainable, features such as post-disturbance **resilience, adaptability** and**diversity**must be present.This is because of the need to regain forms and functions after disturbance, adjustto the new form to continue functioning even without full regain, andto take advantage of available bioresources in the post-disturbance modification of forms and functions.

So, it is aboutusing natural and non-renewable resourcesin such a way that they can regenerate their productive capacity as well asskillful application of sound biological/ecological principlesto farming systems that have minimal or no adverse effects on the environment, thereby protecting the environment.The goal is to meet society's present food and textile needs without compromising the ability for current or future generations to meet theirs.This goal has three main interdependent components – environmental health, economic profitability, and social equity (**Figure 2**).

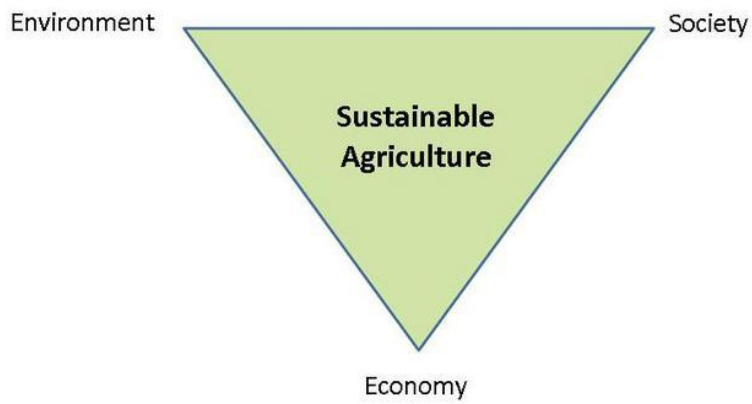

Figure 2: The three main interdependent components of agricultural sustainability

The expansion of industrial productionand the associated releases of GHGs causing climate has meant that agroecosystems and food systems need to be more sustainable. Agriculture's ability to adapt to climate change is now considered as part of what constitutes sustainableagriculture.

Sustainable agricultural practices and climate change response with focus on tropical region The prevailing high-intensity rainfall and temperatures in the tropics confer on this region high turnover rate of soil organic matter which defines soil quality. Also, most of the soil resources of sub-Saharan African are rather of sandy texture, with the majority of these soils constrained by low water retention capacity and excessive leaching of base-forming nutrient elements and hence low soil pH and low-fertility status (Igwe 2011). This situation, particularly the low levels of soil organic matter, makes for ‘fragile’ agroecosystems in the region. Yet, we overstretch these soils inour conventional farming systems.And these farming systems are largely characterized by a stack lack of clearly defined water control and management practices, translating into further loss of nutrients and productivity.The adverse effects of these poor water control/management systems on agriculture and the environment are pronounced in the more humid zonesof which oursoutheastern Nigeria is part of. These peculiarities of sub-Saharan Africa, among other factors, render the sub-region second to none in terms of vulnerability to climate change (Kotir 2011).

In view of the high spate and level of debilitating anthropogenic activities and the associated harm to the biophysical environment in sub-Saharan Africa, farming systems thatpromote build-up of soil organic matter are, more thanever before, needed in this sub-region.The required increases in soil organic matter translate into increased sequestration and storage of carbon in the soil, implying that such farming systems can help to reduce the concentration of carbon in the atmosphere in the form of CO_2, which is the most devastating of the three GHGs causing climate change. By improving the soil structure and hydraulic properties including infiltration and water retention, enhanced status of soil organic matter could also help toreduce wind and water erosion.

Common agricultural practices with great potentialto contribute to agricultural sustainability in tropical Africa towardsachieving global food and nutrition securityinclude:

- growing of indigenous species to restore natural ecological balance;
- mixed cropping for stratified extraction and enhanced use efficiency of water and nutrients;
- mixed cropping to enhance biodiversity that could deflect pests;
- integrated soil fertility management (ISFM) to enhance organic matter, water and nutrients;
- crop rotation to recycle nutrients and break the life cycles of pest and disease pathogens;
- cover cropping and live mulching to conserve soil organic matter and water;
- drip irrigation to save water and enhance water and nutrient use efficiency;
- rainwater harvesting to cope with water scarcity and quality issues in agriculture;
- growing of drought-tolerant crops with less irrigation and minimize irrigation externalities;
- integrated pest management (IPM) to minimize environmental pollution;
- small-scale diversified agriculture spatially integrating crop and animal productionin a mixed crop-animal production enterprise to recycle nutrients;
- increased use of renewable energy sources suchas solar and wind power, animallabour and biofuels to reduce the input of external of non-renewable energy sources, etc.

If you ask me to propose **three viable ways of achieving sustainability in agriculture** across agro-environments of sub-Saharan Africa (humid, sub-humid, semi-arid and arid), I would view the quest for sustainability through the lens of a Soil Scientist which I am. Soils must be restored otherwise high-yielding varieties would fail even with adequate rains (Lal, 2011). Because the soil is the base of all forms of agriculture and the most diverse component of the environment, because most of the biotic and abiotic factors against agricultural productivity in the tropics are soil-related, and considering the aforestated peculiarity of agroecosystems and food systems of sub-Saharan Africa; my answer would be that **our agriculture at the level of primary production shouldfirst be made to conform to the use of sound ecological principles in allocating land resources to agricultural enterprises they are most appropriate for.**Then, stakeholdersshould focus on farming and food systems that enhance biodiversity and productivity by concurrently promoting:

- **(i)** soil organicmatter build-up, conservation and management;
- **(ii)** efficiency in water conservation, control, management and soil-water relations; and
- **(iii)** efficiency in nutrient cycling, recycling of agro-waste and resource use.

This is to say that, in the context of sub-Saharan Africa, the primary goal of sustainable agriculture should be to enhance soil quality/health through increased storage of carbon in the soil. By virtue of the high heat capacity of water, soil water plays a critical role in regulating the exchange of mass (water and carbon) and energy in the land–vegetation–water–atmosphere system. Adopting and maintaining good water control and management could thus complement this increased carbon storage by creating the enabling environment for decelerating the rapid loss of soil organic matter. The corresponding loweringof atmospheric CO_2 concentrationand the efficiency in recycling/use of resourcesimplyenhancement in quality of the **environment**, and the response of climate change would be palpable reductions ofits manifestations in the agroecosystems and impact on agricultural productivity. This situationwould lead to increased agricultural productivity to take care of human needs in the **society**and contribute to improvement in our**economy**.

This proposition of sustainable agricultural practices in sub-Saharan African will not be complete without mentioning the ***sawah* ecotechnology**, which is a viableecological engineering approach to agriculture for overcoming the perennially low and fluctuating agricultural productivity in this sub-region. This promising farming model draws its strength from the principle of allocating land resources to agricultural enterprises they are most appropriate for in a given watershed (**Figure 3**), while using the watershed approach to resource distribution in implementing site-specific good water control and management. *Sawah* plays multifunctional roles in tropical African agriculture, including ecological, agronomic, social and economic roles (Igwe and Wakatsuki, 2012). Space and time will not permit us to discuss *sawah*ecotechnologyand its prospects in detail here,but note that the efficiency in water control and managementdue to this farming model is indispensable if we must attain self-sufficiency in food production. In this quest of ours for sustainabilityof ouragricultural systems in the face of water-related adversities (be it water scarcity or flood) induced by climate change, such efficiency in water control and managementcould serveas an effective mitigation strategy for increased provisioning of ecosystem goods and services.

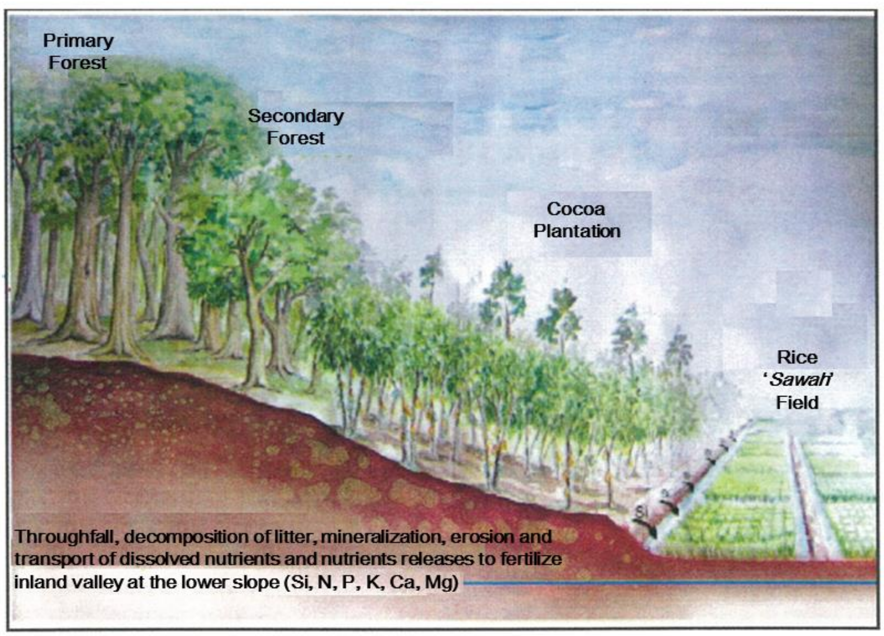

Figure 3: The conceptual illustration of *sawah* farming for tropical Africa model developed by the Forest Research Institute of Ghana.Source: Owusu-Sekyere *et al.*(2010)

Knowledge resource base of Nigeria in the quest for sustainable agriculture To use and manage theenvironment sustainably in the course of practicing agriculture, natural resources are not the only requirement; adequate knowledge is also needed, and this 'intellectual resource' should be such that would match the natural resources at the prevailing scale of agriculture. So, adequacy or otherwise of skilled human resource in this regard is critical. This is because until the largely uninformed masses living in remote villages and communitiesare properly educated on the contributions of unsustainable agricultural practices to the contemporaryclimate changevis-à-vis the prospects of retracing their footsteps, sustainability may remain elusive. Knowledge is key, information is power. There is need to sensitize the people as doing so holds the key to success of the desire and bid to enthrone sustainability in our agriculture.

If the requisite knowledge rests with the skilled manpower in agriculture, then any country aspiring to attain sustainability must evaluate its skilled human resource base. In the case of Nigeria, my experience as a key player inthe training of future agriculturists is that such training under the various degree programmes in Agriculture has changed form. Low enrolment of students into these programmes was the problem in the recent past, but it is no longer so. The emerging problem is sheer lack of passion and interest in agriculture by those receiving training in Agriculture, and this is not a good development for us as far as the campaign for sustainable agriculture is concerned. Strategies are, therefore, urgently needed not only on how to entice young school leavers to opt to read Agriculture as suggested by the current move by the National Universities Commission (NUC) to revert from a five-year to a four-year programme,but also to change their ill-conceived perceptions about agriculture and truly make Agriculture their vocation. It is only by doing so that training of the youth in Agriculture would add value to the course of sustainable agriculture.

Looking into the future with hope It is hoped that our humble efforts in dutifully engaging in sustainable agricultural practices that are compatible with our sub-region of tropical Africa as well as in raising a sustainability-conscious upcoming generation of agricultural practitioners would yield the desired results. Besides the numerous local benefits to us in our immediate environment, such efforts would ultimately helpto advance the Paris declaration of 4 per Thousand (4PT) Initiative “Soils for Food Security and Climate” that strives to address global climate change via the aspirational goal of enhancing the carbon stock on a large portion of the world’s managed soils by an average annual increase of 0.4%. Such a level of adherence to the principles of sustainability in our agriculture would place us in the world map of environmental stewards, and the possibility of earning carbon credits in the distant future may not be ruled out.

I will round off by posing that there is great potential for agricultural sustainability in tropical Africa typified by Nigeria. Soil and water conservation and management practices in this regard must focus on soil organic matter as well as on water and nutrient resources, while concerted efforts are needed to increase the efficiency of recycling and use of agro-waste. Who says we cannot get to a point of zero agro-waste in our agriculture, translating into full operation of the trending concept of circular economy? With the ever-increasing pressure on land resources for agriculture,we should maximize production onavailable land for as long as possible – and that is what sustainable agriculture is all about. I urge us all, agriculturists, engineers, farmers and other relevant stakeholders including the general public to be involved. All hands must be on deck, otherwise the world will leaveus behind if we opt to lose ourenvironment and hence our future, thereby bequeathing hardship to our children and unborn generations. The task may look daunting, but the time to initiate action and/or consolidate on progresses so far made is now.

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LEAD PAPER

The Study of Agriculture in the Universities and the new Core Curriculum Minimum Academic Standards (CCMAS) of the National Universities Commission (NUC)

Chinedum Nwajiuba

Prochancellor, Federal University of Agriculture Zuru, Nigeria, and Visiting Scholar, National Universities Commission, Abuja, Nigeria

Lecture for the 1st Faculty of Agriculture International Conference at the Nnamdi Azikiwe University Awka, 23rd March 2023

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PROLOGUE

"The man who farms as his forefathers did cannot produce much food no matter how rich the land or how hard he works. The farmer who has access to and knows how to use what science knows about soils, plants, animals, and machines can produce abundance of food though the land be poor. Nor need he work nearly so hard and long. He can produce so much that his brothers and some of his neighbours will move to town to earn their living." —T W Schultz (1964) (Noble Prize winner for Economics, 1979)

Dear friends and colleagues, at some point, I will come back to this statement by Prof. Theodore Schultz. That is all I say about that for now.

APPRECIATION

It is proper that I start by expressing my deep appreciation for the opportunity to speak at this conference. I am particularly grateful to the Vice-Chancellor, Prof. Charles O. Esimone, and the entire university for this privilege.

I thank the Faculty of Agriculture, Dean, Staff, and students. I also thank very warmly the organizing committee of this conference. You have done well

Caveat

I have chosen a style for myself when invited to speak for some time now. It is a problem-solving, non-technical, easy to understand street-level approach.

I therefore issue a caveat. Dear colleagues and friends, I rarely do technical papers these days. By this I mean the types we have done over the years to earn the titles we have acquired. I state this so that younger academics and students do not misunderstand my approach here. These days, I devote more efforts at such opportunities as this, at addressing practical problems and hoping that we can together find solutions by which we can improve our wellbeing and that of millions of our suffering people.

This is also community service, a matter, I also observe that academics and universities are struggling with. Our communities service, the third in our line of goals, the first being teaching/learning and the second being research, should be in the context of what we teach and research, and not something far from the university mandate. Such offices as chair or secretary of village meetings and church groups do not qualify as community service in the university system. This is a challenge to many colleagues as revealed last year when the NUC asked for submissions on community service during the collation of data/information for ranking universities. The very hardworking Director Academic Planning (DAP) of this university who I believe was part of that effort, as with all other DAPs will easily remember the struggles in getting our universities properly respond to the request for information on community service.

Therefore, this should be considered my **first contribution here: Get the community service responsibility right**.

Following from this, may I also humbly appeal that the outcomes of this conference and other conferences should not end in papers on bookshelves and conference proceedings or even journals. We should transit to producing simple policy briefs, and community action papers which will be less technical, and easy to read and delivered to the policy and governing groups and as well as communities from whom we often generate our data as we very often state in the justification/need for our study and research.

Universities globally have arrived at a point of needing to justify their existence. We in the universities are weak at marketing our products. **That will be my second contribution here: ensure that in your research and in this conference, take the extra step beyond the conference proceedings, by sending to governments and communities, findings and recommendations that affect them, stating what needs to be done, and by whom, requiring what resources, over what period, with what expected deliverables.**

INTRODUCTION

The National Universities Commission (NUC), the body created by Law to oversee standards and quality in the Nigeria university system late last year unveiled a new curriculum of programmes in the Nigeria university system, and in so doing moved from the Benchmark Minimum Academic Standards (BMAS) that we are all familiar with to the Core Curriculum Minimum Academic Standards (CCMAS). It is therefore proper that in this period, Nigeria universities should pay attention to, and explore this.

Therefore, when I was given the privilege of choosing the topic to speak on, I decided it has to be in the context of the new CCMAS. I have chosen to speak on the study of Agriculture in the universities and the new CCMAS.

For some personal reasons, I could relate aspects of this to the 2016 conference of the Association of Deans of Faculties of Agriculture in Nigeria universities, hosted in this university. I was invited to speak, and I made some contributions bothering on the need to look at the current situation with studying agriculture in the university system in Nigeria.

Since then, something of great significance is the shift by the NUC from the BMAS to the CCMAS. We must commend and appreciate the NUC and her leadership, especially the Executive Secretary (ES), Prof. Abubakar Adamu Rasheed for this significant achievement under his watch.

Curriculum review should be a regular exercise. New knowledge and experiences arise from time to time. New imperatives of society and economy, as well as the expectations of employers of labour should inform the update of curriculum. This has informed the work done by the NUC.

Ideally the Universities should drive this, but our reality is that we may not yet be there. The NUC has provided leadership by driving the 70% core of curriculum. Universities will have to provide the balance 30%. These are not expected to be the same for all universities. Universities therefore have space to create a niche for themselves. The expectation is that with time the NUC 70% will be gradually reduced, and the universities 30% will be gradually increased. That is academic freedom and that is universities maturing and taking confident positions in the firmament of global knowledge enterprise.

In this presentation we focus on agriculture in the CCMAS. Before proceeding, let us reflect on the message of the 2016 presentation.

Recap: Awka 2016

My key message here at the Nnamdi Azikiwe University Awka during the 2016 Conference/Meeting of Association of Deans of Faculties of Agriculture in Nigerian Universities is what I refer to. All academics in the faculties of Agriculture in the Nigeria university system know that we are about the least subscribed by prospective students via the Joint Admissions and Matriculation Board (JAMB) Exercise. This situation is so critical that I have christened them scavenger programmes. By this I mean that since we usually do not have enough applicants, except perhaps one or two programmes in the Faculties of Agriculture, we are forced to scavenge for students. JAMB statistics eloquently shows this.

According to JAMB about 1.8 million candidates sat for the 2022 UTME Exams (https://rsuadmissionguide.com/jamb-announces-statistics-of-courses-applied-in-2022-exam/). A breakdown of these applicants is as follows:

Medicine had the highest number of applicants with **367,499** candidates, while available spaces were only **43,717** slots available in the country. The reported cited put this at above **11%** of the total applicants.

Social Sciences had **231,907** candidates applying for **93,277** slots.

Science had **204,734** applicants for **132,796** slots.

Technology-related courses had **103,891** for the **60,199** slots available (this includes **Engineering** programmes).

Law had **81,653** applicants for **8,529** slots.

Arts and Humanities had **72,014** applicants for **48,744** slots.

Education had **53,612** candidates applying for **111,601** slots.

Agriculture had **21,568** candidates applying for **31,217** slots.

Education and Agriculture had more available spaces than the number of students applying for them.

In agriculture, the students we mostly end with are usually persons who did not *a priori* apply to study any of the programmes in agriculture in the universities. They are mostly, "put me somewhere students".

They come with a lot of baggage, chiefly not being sufficiently motivated, and always on the look out to change to some other programmes.

That does not have to be so. Among the reasons for this low patronage is that very few young persons want to study agriculture.

The practice of agriculture in Nigeria is not "***Kool***", fashionable, nor exciting.

The entry requirements are almost the same for Medicine, Pharmacy, Engineering, microbiology, Biochemistry, and similar courses. Not even Professors in the programmes of Agriculture commonly encourage their own biological children and wards to apply to study any of the programmes in agriculture when they have these entry requirements.

The courses are five-year programmes for those coming in with the SSCE. This is the same number of years as Engineering, Pharmacy, among others. This is also one year more than Biochemistry, Microbiology, etc.

Upon graduation, there are no additional benefits for this extra one year.

At inception of the study of Agriculture in our universities, and until sometime in the mid-1970s, in the era of the Oil boom, the study of agriculture was four years for those with the SSCE and 3 years for those with A-levels. This was changed by choice, moving from the 4-year BSc to the 5-Year B. Agric. The expectation was that the B. Agric graduate will be employed in the civil service and placed on salary Grade Level 09. That never happened. In any case the interest in university education in contemporary Nigeria is no longer employment in the civil service. That era is gone.

Further the same programmes are still offered as B.Sc. (Not B. Agric) in Ghana or the UK, and the US. Young Nigerians who study in those countries return and get into the NYSC, hypothetical one year ahead of their peers.

What has the NUC done with the agriculture curriculum?

What the NUC has done with the CCMAS include the following:

- Grant greater powers to the universities and their senate.
- Unbundled the B. Agric. and have options of B.Sc. in each discipline. Examples are B.Sc. Agricultural Economics, B.Sc. Agricultural Extension, B.Sc. Animal Science, B.Sc. Crop Science, B.Sc. Soil Science, etc.
- Make possible two options: retaining the 5-year B. Agric. and having the new 4-year B.Sc. You may choose the 4-year B.Sc. or the 5-year B. Agric. Each University and her senate should make a choice. The NUC is not forcing any of these two options on the universities. That is academic freedom.

How does this relate to the prevailing culture of scavenging for students?

Deriving from my earlier concern about the study of Agriculture becoming scavenger disciplines we need to remind ourselves what we perhaps know. Many young persons may not find the study of agriculture "***Kool***" at the time of choosing what to study, but we have seen that those who graduate in the various disciplines of agriculture have better opportunities and excellent career opportunities not just in Nigeria but also globally.

Those who persevere become happier with what they can do in and outside Nigeria. Many of the courses the young people find "***kool***" at 16 to 18 years turn out to have comparatively less opportunities after graduation. In addition, by our level of development and the challenges we face, agriculture should be well patronized. It is perhaps the most important challenge we face as a country and most of the developing world.

Agriculture and the University

A university system must be relevant to the national circumstance and must adapt to solving national problems. As many persons realise, there are so many opportunities for those who study programmes in agriculture in the universities, but these are often not known to young people.

There are several serious issues which the university should be addressing. These include:

- Huge challenges with agriculture in Nigeria, the huge deficits in food supply and raw materials provisions, which all indicators show may be worse in the future.
- Predictions of global food challenges and rising food cost.
- Significant urban immigration, with Nigeria urban population galloping.
- Aging farming population.
- Reduced number of those who can farm or the inability of producing and raising the next generation of farmers.
- Continued low technology and use of rudimentary technologies.
- Climate change.

How do we encourage students to study agriculture?

The universities must have to find ways of encouraging students into programmes in agriculture. All over the serious world, certain sectors are considered critical to national security, including agriculture, especially food security. Most of the more developed parts of the world provide support and incentives for agriculture.

To address the aging farming population in Nigeria, with a reduced ability to produce the next generation of farmers, **we must find incentives for students of agriculture.** We must also make their training more practical and more hands-on. We must make university education for university students entrepreneurial based. We must raise the agribusiness sector and we must raise the level of farm technologies. It should not be out of place to have scholarships for students of agriculture. We should commence support for students to embark on agricultural ventures and start-ups. Federal and state government will have to be made to address these. **These represent my third contribution**.

In a nutshell, what **do we need to do to raise a new generation of farmers to replace the aging farming population?** We should creatively make the study of agriculture more exciting and more practical, modernize agriculture and shift to technology, and develop food and agriculture processing technologies. This is also an area that you could factor into your 30% of the CCMAS. **That would be my fourth contribution.**

Of relevance to the challenges of scavenging for students to study agriculture is the recent introduction of Central Admissions Processing System (CAPS) by JAMB. By this, the ability of universities to seek out and offer prospective students places in programmes in agriculture is constrained. **This leads me to my fifth contribution: JAMB should look at the CAPS admission process and grant heavily undersubscribed programmes concessions of inviting prospective students to Agriculture programmes, and then advising them to change online as required by JAMB.** This is slightly different from what we have now which is that the prospective students should first change on the CAPS before being admitted to Agriculture. The Association of Vice-Chancellors of Nigeria Universities, and the Committee of Vice-Chancellors of Nigeria Universities should take this up with JAMB.

After six decades of agriculture and the universities in Nigeria – What impact?

Suppose there were no universities in Nigeria offering degrees in agriculture, what would our country be missing? Put differently what has been the impact of over six decades of universities (from the Nsukka generation of 1960) offering degrees in agriculture in Nigeria? What is the impact of the faculty of agriculture at the Nnamdi Azikiwe University Awka?

Are we dealing with a phenomenon akin to the famous line, 'water, water everywhere and not a drop to drink', in Samuel Taylor Coleridge's poem, 'The Rime of the Ancient Mariner'? PhDs and professors are increasing, but our problems in agriculture are unsolved.

I now return to the words of Prof. Theodore Schultz:

"The man who farms as his forefathers did cannot produce much food no matter how rich the land or how hard he works. The farmer who has access to and knows how to use what science knows about soils, plants, animals, and machines can produce abundance of food though the land be poor. Nor need he work nearly so hard and long. He can produce so much that his brothers and some of his neighbors will move to town to earn their living." —T W Schultz (1964) (Noble Prize winner for Economics, 1979)

Prof. Schultz devoted much of his career to how education, technology and financial incentives significantly raises productivity. Today we can add to this list from Prof. Schultz, that markets also impact on productivity. Insecurity disrupts markets, and adversely affect agriculture. Examples can be seen in the war in Ukraine and the conditions in many places in northern Nigeria. A recent addition is the instability in the market arising from a policy confusion such as the recent naira redesign in Nigeria. That is also disrupting the markets as farmers desperately in need of Naira notes are selling at considerably reduced prices. That may likely adversely affect the following farming seasons, and therefore not just production but productivity.

While reflecting on the lessons of the views of Schultz, which is focused on technology and agriculture, I present an extract from the book by Olaudah Equiano: The Interesting Narrative of the Life of Olaudah Equiano (1789).

"Our tillage is exercised in a large plain or common, some hours walk from our dwellings, and all the neighbours resort thither in a body. They use no beasts of husbandry; and their only instruments are hoes, axes, shovels, and beaks, or pointed iron to dig with."

(Source: https://docsouth.unc.edu/neh/equiano1/equiano1.html, Page 22). The Interesting Narrative of the Life of Olaudah Equiano, or Gustavus Vassa, the African. Written by Himself. Vol. I: Electronic Edition.

What is of interest here is Oladuah's description of the state of agricultural technology in Igboland in the eighteenth century. Three centuries after we are still at the hoe and cutlass technology level. Six decades of universities and agriculture, the situation is not different. Many PhDs and Professors down the line, what impact are we having? How do we justify our existence?

The need for universities to justify their existence is a global one. Nigeria is not exempt. The number of Nigerian universities, faculties of agriculture, and the number of professors in agriculture has increased since 1960. What have we got to show for it?

I present some statistics on professors in agriculture in the Nigeria university system (Table 1). These professors are listed under the following categories and with the accompanying figures:

Table 1: Distribution of agriculture professors according to disciplines

Discipline	Number of Professors
Agribusiness	5
Agricultural Economics	86
Agricultural Extension	53
Agricultural Science (5-year option)	21
Animal Science	114
Crop Science	94
Family and Consumer Sciences	3
Fisheries and Aquaculture	53
Food Science and Technology	26
Forest Resources and Wildlife Management	31
Horticulture and Landscape Management	7
Agricultural Science: Soil Science	43
Water Resources Management and Agro-meteorology	1

Source: NUC, 2022

A note on these figures and categories

There may be over-lap, and some repetitiveness. Nevertheless, it shows a picture of the entries and submissions by DAPs in Nigeria universities. Note also that some persons may have not been listed having not been forwarded by their DAPs. I will leave further comments on this, and you can draw whatever inferences you may on this.

What contribution do I have to make on this as **my sixth**? I have none.

Ending comments

Dear Colleagues and friends, if I have offended you, please pardon. I have put forward five contributions for your consideration. These are:

1. Get the community service responsibility right.
2. Ensure that in your research and in this conference, take the extra step beyond the conference proceedings, by sending to governments and communities, findings and recommendations that affect them, stating what needs to be done, and by whom, requiring what resources, over what period, with what expected deliverables.
3. We must find incentives for students of agriculture.
4. We need to do to raise a new generation of farmers to replace the aging farming population.
5. JAMB should look at the CAPS admission process and grant heavily undersubscribed programmes concessions of inviting prospective students to Agriculture programmes, and then advising them to change online as required by JAMB.

I have however left one for you to fill the gap. In doing that, I will encourage you to see how a major oil-bearing country, Saudi Arabia, has used technology to turn her deserts green, and become an exporter of agricultural products. Please see: https://www.youtube.com/watch?v=HJf6-xIXXJ8. That is the power of science and technology among others, and that is what our universities should be leading our country and people to.

God bless you.

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SUB-THEME 1

PRODUCTION PRACTICES IN SUSTAINABLE AGRICULTURE, NATURE CONSERVATION AND CLIMATE CHANGE RESPONSE

Effects of Palm Oil Mill Effluent (POME) on Smallholder Oil Palm Farming Activities in Agbo Delta State, Nigeria

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ABSTRACT

The growing policy concern on the environment cannot be significantly addressed without strict measures in the case of POME. POME is a highly environmental pollution produced by smallholder oil palm mill operators that affects farming activities and its environment. This study was done to analyze the effects of POME on smallholder oil palm farming activities in Agbo, Delta State with the objectives of examining the socioeconomic features of the farmers and determining the effects of POME on their farming activities. A purposive sampling method was employed to randomly select a sample size of 30 smallholder oil palm farmers and analyzed with descriptive statistics and regression model. The result showed that majority of them were in their middle / old age of 40 to 60 years with 66.7% married while 60% of them had family size of 6 and above and 83.7% of 11 years and above farming experiences. The regression result showed that POME had significant and negative effects on age, labour and plant nutrients at 0.05%, farming experience and farm size at 0.1% and household size at 0.01% with positive and significant effects on soil management practices at 0.1% and annual income at 0.05%. The study recommends a synergy between the farmers and biotechnological and allied research centres in connection with the Ministry of Environment through education/ training on the use of biotechnological tools, POME treatment technologies and intensified soil management practices in their operations to control, maintain and regulate their activities for a friendly and sustainable environment.

INTRODUCTION

The economic importance of oil palm led to its rapid cultivation as the output such as palm oil stands at a significant proportion of 40% of global vegetable oil productions (Krungsri Research, 2016) and 80% palm oil production in Nigeria from dispersed smallholder farmers (Solidaridad. 2020). Smallholder farmers are important actors in oil palm sector (Daemeter Consulting, 2015) – managing and planting between 1-5 hectares in Nigeria (Solidaridad, 2020). These farmers play active role in the various production processes and in the value chain. Some are into production process, processing, marketing, utilization down to consumption. Those into processing are the people that extracts the oil from the fruits leaving fiber, nut, Palm Oil Mill Effluent (POME), among others affecting farming activities.

POME is the voluminous liquid waste that comes from the sterilization and clarification process in milling oil palm containing about 90-95% water with residual oil, soil particles and suspended solids. The production of crude palm oil leads to the proportional production or residue of POME, a pollutant that affects smallholder farming activities. This is in tandem with Perez, (1997) who opined that industrial oil palm mill production of one tonne of palm oil leads to a 2.5tonnes of POME production or one tonne of FFB leads to 0.5 tonne of effluent thereby affecting the environment and farming activities of the farmers. POME is a highly environmental polluting substance causing a lot of negative externalities to the environment such as increasing the cost of labour in soil management practices and maintenance of plant nutrients in farming activities. The negative externalities of POME on farming activities in crop land are its biological oxygen demand (BOD) that affects the life of organisms that are useful, low PH and colloidal nature that requires approximates water treatment needed by half a million people within the polluted environment (Brezing, 1986). POME affects the environment and quality of land as untreated POME readily cause clogging and waterlogging of the soil which kills vegetation including weeds exposing it to degradation that amounts to extra soil improvement practices in their farming activities (Okolie and Ekwuribe, Obasi, Obidiebube and Obasi, 2019). It causes the concentration of major minerals and trace elements that are harmful to living organism required for plant growth (Bankole and Ikhatua, 2009). It is a pollutant that inhibits the growth of soil micro-organisms such as the soil fauna and flora affecting the suitability of the soil for smooth farming activities for crop production. This was observed by Ubani, Onwuneme, Okpashi, Osuji and Nwadike, (2017) who opined that POME is a potent pollutant that inhibits the growth of crops such as Zea may. POME has direct effects on the health of smallholder farmers affecting their capacity for farming activities. It affects farming activities in areas of soil degradation and unsustainable soil resulting to low productivity due to lack of capacity for treated POME with some biotechnological processes and POME treatment technologies such as POMETHANE (Madaki, and Seng, 2013).

However, POME can be of economic benefits when treated with the use of biotechnological processes and modern POME treatment technologies in the sustainable reuse and recovering from waste product to useful one. Treated POME could be used as a cheap organic fertilizer (manure) in farming activities over artificial one (Wu, Mohammad, Jahim, and Anuar, 2009). This is in line with the findings of Oviasogie and Aghimien (2003) that a proper use and safe disposal of POME on the land environment would lead to improved soil fertility and contribute to environmental sustainability for farming activities. The biologically treated POME is used in oil palm plantations for irrigation and as a liquid fertilizer (Wu *et al.*, 2009). Pujono, Kukuh, Evizal, Afandi and Rahmat, (2021) stated that POME applied on land could increase the total number of FFB to 40% significance with 38 harvested FFB per month. Despite all these, most smallholder oil palm farmers are constrained in their farming activities as they lack the capacity to modern POME treatment technologies to ameliorate the effects. The aim of this study was to analyze the effects of POME on smallholder oil palm farming activities with the objective of examining the socioeconomic characteristics and determining the effects of POME on smallholder oil palm farming activities.

METHODOLOGY

This study was carried out in Agbo, Delta State. Agbo is the headquarter of Ika South Local Government Area of Delta State. It is located on latitude 6.2541^0N and longitude 6.2057^0 E on the elevation of 130 meters (427 feet) with a population of 45,800 people (Wikipedia Open Data). The area was purposively chosen because of the high concentration and continuous smallholder oil palm farming activities with so many oil palm mill operations that dumps POME in the area. Information that formed the data were obtained from both primary and secondary sources. Primary data was obtained from a well-structured questionnaire used for the analysis. A purposive sampling method was used to select 30 respondents randomly from the list of smallholder oil palm farmers that were affected by POME in the area. The data were analyzed with descriptive statistics such as the frequencies and percentages for the socioeconomic characteristics like; age, sex, marital status, household size, farming experience, farm size, annual income etc while the regression model was used for the effects of POME on smallholder oil palm farming activities. The regression model is implicitly expressed thus:

$Q = (\alpha + YLnX_n)$……………………………………………………..(1)
Where Q = Effects of POME on smallholder oil palm farming activities
X_1= Age (Years)
X_2 = Labour (Man days)
X_3 = Plant Nutrients (No)
X_4 = Soil Mgt Practice (No)
X_5 = Farming Experience (years)
X_6 = Farm Size (Ha)
X_7 = Household Size (No)
X_8 = Annual Income (₦)
e = Error Term
Explicitly expressed, the Semi-log form becomes:
$Q = \alpha + Y_1LnX_1 + Y_2LnX_2 + Y_3LnX_3 + Y_4LnX_4 + Y_5Ln\ X_5 + Y_6LnX_6 + Y_7LnX_7 + Y_8LnX_8 + e$……………………(2)
Where: Q, X_1, X_2, X_3, X_4 X_5, X_6X_7,X_8, are as stated above, ln= log, α = constant, $Y_1 – Y_8$ = regression coefficients and e = error term.

RESULTS AND DISCUSSION

Table 1 showed that only 16.7% of the farmers were less than 40 years of age while majority of them (83.3%) aged 40 to 60 years which directly or indirectly depend on the surrounding environment like nearby waters that are affected by POME. This is in consonant with Okereke and Ginikanwa, (2020) who opined that discharged POME into waters (rivers, streams or lakes) contaminates it and denies local people the access to good water for domestic uses and fishing. The result from sex showed the male dominance of (83.3%) to females (16.7%), is an indication of male enterprise. According to Mensah, Amegashie, and Gyasie, (2009), acquisition of lands for oil palm plantation or farmland with wild groves is male-dominated enterprise transferred from one male generation to another.

The result further showed that 66.7% of the respondents were married, implying that farming activities and the production of POME is mainly carried out by a greater percentage of married people who in the bid to carry out farming activities and process enough oil to cater for their families thereby polluting the environment. The level of education of 50.0% for non-formal education is a problem as they may not take cognizance of the effects of POME on their farming activities and had effective knowledge that equips them with enough environmental pollution control in relation to health and agri-business. The result also showed that 60.0% of the farmers had household sizes of above 6 persons who supplied family labour and feeds from the farm proceeds. The effects of POME might have a significant and direct effect on them in terms of health risks, non- productivity of land in area of discharged untreated POME as it lowers soil productivity (Okwute, and Isu, 2007).

Table 1: Socio-Economic Characteristics of the Smallholder Oil Palm Farmers

Variables	Frequency	Percentages
Age (yrs)		
30-40	5	16.7
41-50	25	83.3
≥ 50	5	16.7
Total	30	100
Sex		
Male	25	83.3
Female	5	16.7.
Total	30	100
Marital status		
Single	5	16.7
Married	20	66.7
Widowed	4	13.3
Divorced	1	3.3
Total	30	100
Educational level		
Non formal	15	50
Primary	10	33.3
Secondary	3	10
Tertiary	2	6.6
Total	30	100
Household size		
1-5	15	50
6-10	10	33.3
≥ 10	5	16.7
Total	30	100
Experience (years)		
1-10	5	16.7
11-20	10	33.3
21-30	10	33.3
≥ 30	5	16.7
Total	30	100
Annual income (₦)		
50000-100000	5	16.7
150000-200000	5	16.7
≥ 2500000	20	66.7
Total	30	100
Farm Size (ha)		
1-2	20	66.7
3-4	5	16.7
≥ 5	5	16.7
Total	30	100

Source: Field Survey (2022).

The long years of farming experience of 11years and above at (83.3%) indicated that it is a long term business with regards to POME production. This shows that the long discharge of POME to the environment has led to a great environmental pollution in the area with several adverse effects on their farming activities in relation to the inhabitants. Despite the effects of POME, the total annual income of them was moderately encouraging at 66.7% from ₦250000 and above per annum not considering the cost of externalities they have caused to the environment that they are not charged to pay. The farm size showed that 83.4% of the respondents had 1-4 hectares of land on the average at the range of smallholder farmers.

The semi log function was the best fit of the regression analysis having the highest coefficient of multiple determination, R^2 of 0.693, indicating that 69.3% variations of the effect of POME on smallholder oil palm farming activities was accounted for by the included explanatory variables such as age, labour, planting materials, soil management practices, household size, farming experience, farm size and annual income with the Adj R^2 being 0.676 and F-Stat of 18.763. The result showed that age was negatively significant at 0.05%, indicating that POME affects farmers age in terms of health issues which have direct effects on their farming activities. POME has a negative and significant effect on labour and plant nutrients at 0.05% in the area. Therefore it decreases the effectiveness of labour use in farming activities and leads to a gradual decrease in the plant nutrients. This shows that intensification of land area used in crop production is imperative (Okere, 2013). Soil management practices such as the use of mulch materials to protect the soil, use of bush fallow or shifting cultivation, crop rotation system in case of mixed cropping and adequate space distance, early planting among others was positively significant at 0.1%. This indicates that increase in the level of soil management practices cushions the effects of POME as a land degradable substance in farming activities (Okere, 2013). Household size was negatively significant at 0.01% level, indicating that POME affects the functional farming activities of the people as most of their lives revolve within their environment. In this case the outcome of the pollution such as the bad odour emission, the contamination of nearby rivers and the degradation of land directly affects the performance of their farming activities (Okereke and Ginikanwa, 2020). Farming experience and farm size had negative and significant effects at 0.1%. This indicates that despite their long term experience and farm sizes, the effects of POME is a threat as affecting the nutrient availability of plants making the soil to lose its vegetative cover (Okereke and Ginikanwa, 2020) which demands for extra land improvement practices that are cost effective. Annual income was positively significant at 0.05% level. It shows that despite the effects of POME, smallholder farmers are making their gains irrespective of the negative externalities to the environment which they are not paying the cost.

Table 2: Result of the Effects of POME on Smallholder Oil Palm farming activities

Variables	Semi-log
Constant	493492.3
	(1.031)
X_1= Age (yrs)	-73253.11(2.325)**
X_2= Labour (man days)	-09.18 (2.390) **
X_3= Plant Nutrient (No)	-0.002 (2.53) **
X_4= Soil Mgt Practice (No)	3.64 (1.86) ***
X_5= Household size (No)	-0.003(3.101)*
X_6= Experience (yrs)	-0.002(1.6803) ***
X_7= Annual income (₦)	3.124(2.144) **
X_8= Farm Size (ha)	-2.753(1.936) ***
R^2	0.693
Adj R^2	0.676
F-value	18.765

Source: Field Survey 2022. Significant at 10%= ***, 5% = ** and 1% = * respectively

Equation form of the Effects of POME on Smallholder Oil Palm farming activities

Q= 493492.3 - (1.013) - 3253.11 (2.159) X_1** - 09.18 (2.390) X_2** - 0.002 (2.53) X_3** + 3.64 (1.86) X_4*** - 0.003 (3.101) X_5* - 0.002(1.6803) X_6 ***+ 3.124(2.144) X_7** - 2.753(1.936) X_8***

CONCLUSION

POME is a highly environmental pollutant causing a lot of negative externalities within the disposed surroundings from oil mill sites. This study was carried out in Agbo Delta State to ascertain the socioeconomic features and the effects of POME on smallholder oil palm farming activities. A purposive random sampling size of 30 respondents were collected and analyzed with the descriptive statistics and the ordinary least square regression model. The revealed that majority of them were in their middle / old age of 40 to 60 years with 66.7% married, 60% of 6 and above family size and 83.7% of 11 years and above farming experiences. The regression result showed that POME had significant and negative effects on age, labour, plant nutrients. household size, farming experience and farm size with positive and significant effects on Soil management practices and annual income. The study recommends that education is the key to knowledge and knowledge is power. Therefore, there should be a synergy between the farmers and biotechnological and allied research centres in connection with the Ministry of Environment through education / training on the use of biotechnological and POME treatment technologies in their operations to control and regulate the activities and intensify soil management practices for efficient, friendly and sustainable environment.

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Integrated Application of Wood Ash and Inorganic Fertilizers on The Growth and Yield of Garden Egg (*Solanum aethiopicum* L.)

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K E Y W O R D S

Acidic soil,
Garden egg,
Potassium
Wood ash,

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A B S T R A C T

Wood ash is one of the commonly available organic wastes in Nigeria because firewood is a common source of fuel for both rural and urban dwellers and can become an important alternative source of inorganic potassium especially for farmers in areas with acidic soils. Treatments consisted of the application of inorganic fertilizer sources (0 kg ha-1, 130.44 kg ha-1 urea and 300 kg ha-1 NPK 20:10:10) and wood ash (0 t ha-1, 5 t ha-1 ash and 10 t ha-1 ash) to garden egg seedlings in the field using 3 x 3 factorial experiment in randomized complete block design with three replications. Main effect of wood ash showed significant ($p \leq 0.05$) fruit yield in this order: 10 t ha-1 of wood ash > control > 5 t ha-1 of wood ash. The main effect of inorganic fertilizer sources on fruit yield followed this sequence: 300 kg ha-1 NPK 20:10:10 > 130.44 kg ha-1 Urea > control. The interaction of 10 t ha-1 of wood ash and 300 kg ha-1 NPK 20:10:10 produced highest fruit yield (57 t ha-1) while 5 t ha-1 of wood ash produced lowest fruit yield (10.70 t ha-1). Therefore, the application of integrated 10 t ha-1 of wood ash and 300 kg ha-1 NPK 20:10:10 for improved growth and yield of garden egg is recommended to farmers in Awka.

INTRODUCTION

Garden egg (*Solanum aethiopicum* L.) is a crop of solanaceae family. The leaves and fruits are used as vegetables in local delicacies and can be eaten raw in Nigeria. The fruits are known to have medicinal properties such as anti inflammatory, anti asthmatic, anti-glaucoma, hypoglycemic and fat burning property in human (Ayodele, 2018). These healing properties of garden egg can be attributed to the high presence of fibre, ascorbic acid, anthocyanin, glycoalkaloids and alpha-chaconine (Sanchez-Mata *et al.*, 2010). Nutritional studies on garden egg shows that the fruits are rich in fibre, protein and minerals (Yamoah, 2016).

Crop production in tropical zones of Nigeria usually faces the challenge of poor soil productivity because of high rainfall which results in leaching of soil nutrients (FPPD, 1989). Just like nitrogen is very limiting in tropical soil due to its high leaching ability, potassium is also limiting in the rain forest zones because potassium is highly soluble and can also be easily lost through leaching (Thomas *et al.* 2016). Potassium is one of the commonly leached cation because it is easliy displaced in soil solution and it is easliy percolated in sandy soils (Mendes *et al.,* 2016). Fertilizers, lime and humus produce soluble ions are easily lost during rainfall or excessive irrigation through downward percolation of soil water (Thomas *et al.* 2016). Potassium which is a soluble ion can move downwards in the soil profile durring rainfall or excessive irrigation beyond the reach of crop root system.

Wood ash is another source of waste in southeastern Nigeria where the locals and eatery stores rely heavily on wood as source of energy for cooking. These ashes constitute great waste and if not utilized positively can cause environmental pollution. Burning of woods into ash for cooking contributes greenhouse gases to the atmosphere. However, the use of wood ashes in crop production tends to absorb the carbon iv oxide from the atmosphere and convert it into foods by using the ash as lime or manure and wood ash has been reported to improve crop growth and yield in okra (Okoli *et al.,* 2015, Ojeniyi, 2007), cowpea (Ojeniyi and Iderawumi, 2020) . Thus, the utilization of wood ash as lime/manure will reduce contribution of this fossil fuel to climate change and the crops help to reduce carbon iv oxide accumulation in the atmosphere and thereby, purifying our environment.

However, there is lack of awareness, paucity of information on scientific results on the use of wood ash for crop production which has resulted in dumping of these ashes in bushes which are washed into water bodies causing water pollution. When wood ash is used as lime/manure in crop production, wood ash will have increase agricultural and economic value and the threat of indiscriminate dumping of ash to our environment will reduce drastically.

Wood ash can be utilized effectively as lime/manure in garden egg production by integrating it with inorganic fertilizers because, wood ash can only contribute calcium, magnesium, potassium and sodium to the soil with little or no nitrogen, carbon and sulphur (Asadu *et al.*, 2004). High potassium content of wood ash plays a great role in flower and fruit development while inorganic fertilizers which supply nitrogen necessary for vegetative growth (Dursun *et al*, 1999). Therefore, wood ash in the absence of nitrogen fertilizer will not produce optimally high growth and yield in garden egg. Research works on the integrated application of wood ash and inorganic fertilizers have reported improved growth and yield in crops like pepper (Olugbemi, 2019), okra (Iderawumi, 2018), tomato (Ewulo *et al*., 2009) and maize (Awodun *et al*., 2007). However, there is a great paucity of information on the integration of wood ash and inorganic fertilizers for the production of garden egg.

Therefore, this research was conducted to determine the effectiveness of integration of wood ash with inorganic fertilizers to improve the yield of garden egg in poor soils and in the era of scarcity and high cost of inorganic fertilizers.

MATERIALS AND METHODS

Experimental site

The study was carried out in the Teaching and Research Farm of the Department of Crop Science and Horticulture, Nnamdi Azikiwe University, Awka, Nigeria. The research farm lies at the latitude of 06 °15 N and longitude 07 °08 E, with an average annual rainfall of 1810.3 mm and relative humidity of 72.3%. The average minimum and maximum temperatures of the field were 28.74 °C and 28.96 °C with average relative humidity of 63.48% during the experiment (GEOMET-NAU 2021).

Soil of the experimental site and wood ash laboratory analytical methods

Pre planting soil samples were taken at the depth of 0-20cm. The samples were processed following standard laboratory procedures and analysed for the following parameters: soil pH (H_2O) using 1; 1 Soil / water ratio with pH meter, exchangeable bases (Ca^{2+}, Mg^{2+}. K^+ and Na^+) were determined using 1 N NH_4 AOC extractant and the concentration of K^+ and Na^+ in the extract will be read from a flame photometer , while Ca^{2+} and Mg^{2+} concentration were determined from AAS. Available P were assessed by Bray $^{-1}$ method, as described by Okalebo *et al* .,1993. Organic carbon were determined using dichromate wet oxidation (Walkley-Black) method as described by Rowell, 1996. Micro Kjeldhal method as described by Okalebo *et al* . (1993) were deployed for the determination of the soil total nitrogen.

Treatments and experimental Design

The treatments consisted of inorganic sources (0, 130.44 kg ha^{-1} urea and 300 kg ha^{-1} NPK 20:10:10) and wood ash (0, 5 t ha^{-1} ash and 10 t ha^{-1} ash) applied in combination to garden egg seedlings. This experiment was carried out in the field and the experimental design was 3 x 3 factorial experimental design in randomized completely block design with three replications. Each rate in the inorganic fertilizer supplied 60 kg ha^{-1} of nitrogen respectively.

Cultural practices

Garden eggs seedlings were raised in a nursery located at the Teaching and Research Farm of the Department of Crop Science and Horticulture in seedling trays filled standard nursery mixture (Top soil + poultry manure + river sand in the ratio of 3:2:1) and were transplanted when the young seedlings had five leaves and were 20 cm tall by gently lifting up the seedlings with the standard nursery mixture and placing them in their respective holes of raised beds. The seedlings were planted at the spacing of 50 cm between rows and 50 cm within rows. The crop production was carried out under rain-fed condition. The treatments were applied using ring methods one week after transplanting. The nursery and the field were kept weed free by hand pulling and hoeing respectively throughout the period of the experiment. Fruits were harvested from three months after transplanting while still green in colour.

Data collection and analysis

The following growth and yield data were recorded; plant height (measured with measuring tape from ground level to tip apex), number of leaves (physically counting the number of fully open leaves), girth (using vernier caliper at 10 cm above the ground level), number of branches (physically counting the number of branches), number of fruits (counting the number of fruits per plant) and fruit yield (weighing the fruit weight using electronic scale). Growth parameters were measured at 2, 4, 6 and 8 weeks after transplanting (WAT) while yield parameters were measured from 9 WAT. Data collected were subjected to analysis of variance for completely randomized block design using GENSTAT 2009 version statistical software package and means were separated using least significant difference at 5 % level of probability.

RESULTS AND DISCUSSION

Soil and wood ash chemical properties

The soil used for planting is slightly acidic, low in organic matter and has very poor nitrogen content. Wood ash is alkaline in nature and contains high potassium, calcium and sodium with low nitrogen content (Table 1).

Table 1: Chemical properties of soil and wood ash

Elements	Soil	Wood ash
Nitrogen (%)	0.01	1.10
Organic carbon (%)	0.11	6.86
Organic matter (%)	1.51	11.83
Sodium (cmol/kg)	0.03	88.00
Magnesium (cmol/kg)	0.60	21.87
Calcium (cmol/kg)	0.80	68.00
Potassium (cmol/kg)	0.07	440.64
Available phosphorus (ppm)	9.28	38.20
pH in water	5.80	8.20

Main effect of wood ash on the garden growth and yield parameters

Wood ash did not significantly affect plant height at 2, 4 and 8 WAT. Tall garden egg plant (102.10 cm) was produced by the control while the application of 10 t ha^{-1} of wood ash produced dwarf garden egg (85.90 cm) at 6 WAT. There was significant difference between the height of garden egg plants produced with 5 t ha^{-1} (91.30 cm) and 10 t ha^{-1} (85.90 cm) of wood ash (Table 2). Stem girth was not significantly affected by wood ash at 2 and 4 WAT (Table 2). Biggest stem girth was produced by control (5.33 mm) while the smallest stem girth was produced by 10 t ha^{-1} of wood ash (4.79 mm) at 6 WAT. Application of 10 t ha^{-1} of wood ash produced smallest stem girth (4.76 mm) whole control produced biggest stem girth (5.91 mm) at 8 WAT.

Number of leaves was highest in garden egg produced with 5 t ha^{-1} of wood ash (9.31) control (7.33) produced lowest number of leaves at 2 WAT (Table 2). Number of leaves was not significantly affected by wood ash at 4 and 6 WAT, however, at 8 WAT, control produced highest number of leaves (182.20) while the application of 10 t ha-1 of wood ash produced the lowest number of leaves (118.70). Number of branches was highest in garden egg produced with 5 t ha^{-1} of wood ash (2.87) while control produced lowest number of branches (1.84) at 2 WAT (Table 3). Application of 10 t ha^{-1} of wood ash produced lowest number of branches while control produced highest number of branches at 4, 6 and 8 WAT. Number of fruits was highest in control (105.00) while garden egg produced with 5 t ha^{-1} of wood ash produced lowest number of fruits (43.50). Lowest yield of garden egg was observed in garden egg that received 5 t ha^{-1} of wood ash (17.80 t ha^{-1}) while 10 t ha^{-1} of wood ash (33.00 t ha^{-1}) produced highest yield in garden egg (Table 3). Growth parameters such as plant height, stem girth, number of leaves and number of branches were superior in the control while the application of wood ash at 10 t ha^{-1} produced highest fruit yield. The poor performance of growth parameters in relation to the control could be attributed to poor nitrogen content of wood ash (Table 1). According to Okoli *et al*., 2015, palm bunch ash has poor nitrogen and high in potassium with the negative implication on vegetative growth, however, favours fruit yield. This observation of the poor performance of the wood ash on the growth parameters affirms the result of Purwanto *et al*., (2020) who found out that wood ash treatment on pepper significantly affected plant dry weight, root volume, number of fruits per plant and fruit weight per plant but has no significant effect on plant height. The improvement of the fruit weight reiterates the importance of potassium in flowering and fruit development in fruit and fruit vegetable crops. Wood ash has been found to improve pod yield in okra (Ojeniyi, 2007), root yield in carrot (Obidiebube *et al.,* 2022) and cowpea pod yield (Ojeniyi and Iderawumi, 2020).

Table 2: Main effect of wood ash on plant height (cm), stem girth (mm) and number of leaves

Treatments (t ha^{-1})	**Plant height (cm) WAT**				**Stem girth (mm) WAT**				**Number of leaves WAT**			
	2	4	6	8	2	4	6	8	2	4	6	8
0	19.36	52.90	102.10	126.50	1.87	3.29	5.33	5.91	7.33	40.30	90.60	182.20
5	21.46	49.80	91.30	120.10	1.94	3.39	5.27	5.00	9.31	41.90	88.60	128.20
10	21.33	48.50	85.90	104.70	1.58	3.32	4.79	4.76	7.82	41.50	84.80	118.70
LSD $_{(0.05)}$	3.06	7.62	9.72	18.92	0.31	0.37	0.43	0.77	1.18	6.08	6.82	36.07
Significant level	NS	NS	**	NS	NS	NS	*	**	**	NS	NS	**

NS = Non significant, * = Highly significant, ** = Significant

Table 3: Main effect of wood ash on no of branches, number of fruits and yield (t ha^{-1})

Treatments (t ha^{-1})	No of branches WAT				No of fruits	Fruit yield (t ha^{-1})
	2	4	6	8		
0	1.84	15.11	14.89	21.11	105.00	31.10
5	2.87	11.53	11.53	15.13	43.50	17.80
10	2.07	11.20	11.20	12.38	64.90	33.00
LSD $_{(0.05)}$	0.83	2.98	3.11	4.30	44.62	12.18
Significant level	*	*	*	**	*	*

NS = Non significant, * = Highly significant, ** = Significant

Main effect of inorganic fertilizers on the garden growth and yield parameters

Application of 300 kg ha^{-1} of NPK produced significantly tallest garden egg at 2 (23.64 cm), 4 (55.60 cm), 6 (105.80 cm) and 8 (132.20 cm) WAT while control produced dwarf garden egg at 2 (16.26 cm), 4 (42.70 cm), 6 (83.50 cm) and 8 (110.00 cm) WAT (Table 4). Stem girth was not significantly affected by inorganic fertilizer application at 2, 4 and 8 WAT (table 4). Number of leaves was highest in garden egg produced with 300 kg ha^{-1} of NPK (10.76) and lowest in control (6.38) at 2 WAT (Table 4). Number of leaves was not significantly affected by inorganic fertilizers at 4 WAT. Number of leaves was highest in garden egg produced with 300 kg ha^{-1} of NPK (111.80) and lowest in control (73.40) at 6 WAT. Application of 300 kg ha^{-1} of NPK produced highest number of leaves (178.00) while the application of 130.44 kg ha^{-1} of Urea produced lowest number of leaves (124.50) at 8 WAT. Number of branches was highest in garden egg produced with 300 kg ha^{-1} of NPK (3.91), followed by the application of 130.44 kg ha^{-1} of urea (1.91) and lowest in control (0.96) at 2 WAT (Table 5). Number of branches was not significantly affected by inorganic fertilizers at 4, 6 and 8 WAT. Number of fruits was not significantly affected by inorganic fertilizers. Highest fruit yield was produced by the application of 300 kg ha^{-1} of NPK (41.00 t ha^{-1}) while the control (13.10 t ha^{-1}) produced lowest fruit yield (Table 5). The inorganic fertilizer sources showed a significant effect on the growth and yield parameters in relation to the control. Both urea and NPK fertilizer increased growth parameters with respect to plant height, stem girth, number of leaves and number of branches. The significant effect of inorganic fertilizer sources on the growth and yield parameters could be attributed to the supply of nutrient elements such as nitrogen by urea and NPK fertilizers as well as phosphorus and potassium by NPK fertilizer. This result agrees with the findings of Okoli *et al* (2015) on the improvement of okra height, number of leaves, leaf area and number of pods by NPK 15:15:15 fertilizer with respect to the control. Urea fertilizer significantly outperformed the growth and yield control garden egg. Urea supplied nitrogen element necessary for the growth of the garden egg in a very poor soil. This confirms the work of Masome, (2013) who stated that nitrogen from urea are effective on the growth and reproductive factors of tomato. Increasing rates of nitrogen from urea increased the growth and fresh fruit yield of African eggplant in relation to zero application of urea (Olunloyo *et al.,* 2019). The result shows the superiority of 300 kg ha^{-1} of NPK over 130.44 kg ha^{-1} of urea on the growth and yield performance in garden egg. Both inorganic fertilizers supplied 60 kg ha^{-1} of nitrogen, however, NPK fertilizer also supplied phosphorus and potassium elements which boosted the vegetative and yield parameters of garden egg. Nitrogen is responsible for plant vegetative growth and development, phosphorus is involved in root growth while potassium increases photosynthesis capacity, strengthens cell tissue, activates the absorption of nitrates, stimulates flowering and fruit development in tomato and eggplant (Dursun *et al*., 1999). Deficiency of these nutrient elements in the soil as reported in Table 1 will result in poor vegetative growth, root development and flower initiation and fruit yield. Therefore, garden egg cultivated with NPK fertilizer became superior to garden egg cultivated with urea in terms of plant height, stem girth, number of leaves, number of branches, number of fruits and fruit yield. These findings confirms the results of Adeyeye *et al.,* (2018), who reported that NPK fertilizer increased number of leaves, number of nodes, number of flowers and fruits in tomatoes in relation to urea.

Table 4: Effect of inorganic fertilizer sources on plant height (cm), stem girth (mm) and number of leaves

Treatments ($kg\ ha^{-1}$)	Plant height (cm) WAT				Stem girth (mm) WAT				Number of leaves WAT			
	2	4	6	8	2	4	6	8	2	4	6	8
0	16.26	42.70	83.50	110.00	1.71	3.19	4.82	4.89	6.38	40.40	73.40	127.20
130.44 $kg\ ha^{-1}$ of Urea	22.24	52.90	90.00	109.10	1.80	3.46	4.99	5.02	7.33	39.50	78.90	124.50
300 $kg\ ha^{-1}$ of NPK	23.64	55.60	105.80	132.20	1.88	3.34	5.58	5.76	10.76	43.80	111.80	178.00
LSD (0.05)	3.06	7.62	9.72	18.92	0.31	0.37	0.43	0.77	1.18	6.08	6.82	36.07
Significant level	**	**	**	*	NS	NS	*	NS	**	NS	**	**

NS = Non significant, * = Highly significant, ** = Significant

Table 5: Effect of inorganic fertilizer sources on number of branches and yield parameters

Treatments ($kg\ ha^{-1}$)	Number of branches WAT				No of fruits	Fruit yield ($t\ ha^{-1}$)
	2	**4**	**6**	**8**		
0	0.96	11.16	11.16	15.11	53.10	13.10
130.44 $kg\ ha^{-1}$ of Urea	1.91	12.64	12.42	15.49	80.40	27.80
300 $kg\ ha^{-1}$ of NPK	3.91	14.04	14.04	18.02	81.70	41.00
$LSD_{(0.05)}$	0.83	2.98	3.11	4.30	44.62	12.18
Significant level	*	NS	NS	NS	NS	*

NS = Non significant, * = Highly significant, ** = Significant

Interaction effect of wood ash and inorganic fertilizer on the growth and yield of garden egg

Interaction of 5 $t\ ha^{-1}$ of wood ash and 300 $kg\ ha^{-1}$ of NPK produced significantly tallest garden egg (30.23 cm) while control produced dwarf garden egg (16.10 cm) at 2 WAT (Table 6). There was no significant difference between heights of garden egg produced by the interaction of 5 $t\ ha^{-1}$ of wood ash and 300 $kg\ ha^{-1}$ of NPK (30.23 cm) and interaction of 10 $t\ ha^{-1}$ of wood ash and 130.44 $kg\ ha^{-1}$ of urea (27.20 cm). Interaction of 5 $t\ ha^{-1}$ of wood ash and 300 $kg\ ha^{-1}$ of NPK produced tallest garden egg while 10 $t\ ha^{-1}$ of wood ash produced dwarf plants. Interaction effect of wood ash and inorganic fertilizer did not significantly affect garden egg height at 6 and 8 WAT. Stem girth was broadest in garden egg produced with the interaction of 5 $t\ ha^{-1}$ of wood ash and 300 $kg\ ha^{-1}$ of NPK and narrowest in garden egg produced with 10 $t\ ha^{-1}$ of wood ash at 2 WAT (Table 6). Stem girth was not significantly affected by the interaction of wood ash and inorganic fertilizer at 4, 6 and 8 WAT. Number of leaves was highest in garden egg produced with the interaction of 5 $t\ ha^{-1}$ of wood ash and 300 $kg\ ha^{-1}$ of NPK at 2 and 4 WAT while the application of 5 $t\ ha^{-1}$ of wood ash produced lowest number of leaves at 2 and 4 WAT (Table 6). Highest number of leaves was observed in garden egg produced with the interaction of 5 $t\ ha^{-1}$ of wood ash and 300 $kg\ ha^{-1}$ of NPK at 6 and 8 WAT while the application of 5 $t\ ha^{-1}$ of wood ash and 130.44 kg ha^{-1} of urea produced lowest number of leaves at 6 and 8 WAT. Number of branches was significantly highest in garden egg produced with the interaction of 5 $t\ ha^{-1}$ of wood ash and 300 $kg\ ha^{-1}$ of NPK (7.07) and lowest in garden egg produced with 5 $t\ ha^{-1}$ of wood ash (0.33). However, there was no significant difference on the effect of the interaction of wood ash and inorganic fertilizer on the number of branches at 4, 6 and 8 WAT (Table 7). Number of fruits was significantly highest in garden egg produced with 130.44 $kg\ ha^{-1}$ of Urea while garden egg produced with 5 t ha-1 of wood ash produced lowest number of fruits. Fruit yield was not significantly affected by the interaction of wood ash and inorganic fertilizer. However, on mean basis, the application of 10 $t\ ha^{-1}$ of wood ash and 300 kg ha^{-1} of NPK (57.00 $t\ ha^{-1}$) produced highest yield, followed by urea (39.90 $t\ ha^{-1}$) while 5 $t\ ha^{-1}$ of wood ash produced the lowest yield (10.70 $t\ ha^{-1}$). Interaction of wood ash and NPK fertilizer and interaction of wood ash and urea improved growth and yield parameters than the individual application of urea, NPK fertilizer and wood ash. This is to show that integrated application increased the higher quantity of nutrient availability (potassium, phosphorus and nitrogen) to the garden egg plants in relation to individual application of the other treatments. However, integrated application of wood ash and NPK fertilizer outperformed integrated application of wood ash and urea, even though urea and NPK fertilizer supplied the same quantity of nitrogen (60 kg ha^{-1}). The better performance of integrated application of wood ash and NPK fertilizer in relation to the integrated application of wood ash and urea could be attributed to the availability of higher amount of phosphorus and potassium available to the garden plants which improved the growth and yield of the garden egg. The above results confirm the findings of Ayeni (2008) in a multi-locational studies which stated that the combination of 10 t ha^{-1} of cocoa pod ash and 100 kg of NPK 20:10:10 fertilizer gave highest number of leaves, number of branches and fruit yield in tomato at Fagun (trial 1 and 2). Similar results were corroborated by Ewulo *et al.*, 2009 who reported increase in height, number of leaves, stem girth, biomass, number of fruits and fruit weight in tomatoes when cultivated with sawdust ash and urea in relation to single application of urea and sawdust. Olugbemi (2019) reported similar results as observed by Ayeni (2008) and Ewulo *et al*, (2009) in pepper grown with wood ash and urea.

Table 6: Interaction effect of wood ash and inorganic fertilizer on plant height (cm stem girth (mm) and number of leaves

Treatment combination		Plant height (cm)				Stem girth (mm)				Number of leaves			
(t ha^{-1})	(kg ha^{-1})	WAT				WAT				WAT			
		2	4	6	8	2	4	6	8	2	4	6	8
0	0	16.10	49.30	95.90	126.40	2.03	3.40	5.33	5.70	7.930	40.70	76.40	191.10
0	Urea	21.90	57.40	110.70	127.50	1.87	3.27	5.23	6.13	7.93	43.30	100.50	203.70
0	NPK	20.07	52.10	99.90	125.50	1.70	3.20	5.43	5.90	6.13	36.90	94.90	151.90
5	0	16.50	57.40	76.60	101.80	1.73	3.13	4.63	4.47	5.40	36.40	66.00	94.10
5	Urea	17.63	45.20	88.10	110.00	1.70	3.53	5.23	4.70	5.67	36.90	64.40	87.10
5	NPK	30.23	66.20	109.20	148.60	2.40	3.50	5.93	5.83	16.87	52.50	135.50	205.30
10	0	16.17	40.90	78.10	101.80	1.37	3.03	4.50	4.50	5.80	44.00	77.80	96.40
10	Urea	27.20	56.20	81.90	89.80	1.83	3.57	4.50	4.23	8.40	38.20	71.70	82.80
10	NPK	20.63	48.50	97.60	122.60	1.53	3.33	5.37	5.53	9.27	42.10	105.00	176.90
$LSD_{(0.05)}$		5.31	13.19	16.83	37.77	0.54	0.64	0.74	1.33	1.18	6.08	6.82	62.47
F-Probability		**	*	NS	NS	*****	**NS**	**NS**	NS	**	*	**	**

NS = Non significant, * = Highly significant, ** = Significant

Table 7: Interaction effect of wood ash and inorganic fertilizer on number of branches and yield parameters

Treatment combinations		**Number of branches WAT**				Number of fruits	Fruit yield (t ha^{-1})
(t ha^{-1})	(Kg ha^{-1})						
		2	**4**	**6**	**8**		
0	0	1.60	14.87	14.87	21.33	127.20	15.80
0	Urea	2.47	16.87	16.20	24.07	140.40	39.90
0	NPK	1.47	13.60	13.60	17.93	47.40	37.20
5	0	0.33	8.93	8.93	12.20	9.00	10.70
5	Urea	1.20	10.60	10.60	12.27	25.50	14.00
5	NPK	7.07	15.07	15.07	20.93	101.40	28.80
10	0	0.93	9.67	9.67	11.80	23.10	12.80
10	Urea	2.07	10.47	10.47	10.13	75.40	29.40
10	NPK	3.20	13.47	13.47	15.20	96.30	57.00
$LSD_{(0.05)}$		1.44	5.16	5.38	7.43	77.29	21.09
F-Probability		**	NS	NS	NS	*	NS

NS = Non significant, * = Highly significant, ** = Significant

CONCLUSION AND RECOMMENDATION

The main effect of wood ash showed that 10 t ha^{-1} of wood ash produced highest fruit yield without commensurate improvement on the growth parameters. The inorganic fertilizer showed the superior effect of 300 kg ha^{-1} of NPK over 130.44 kg ha^{-1} of urea on the growth and yield parameters of garden egg. Integrated application of 10 t ha^{-1} of wood ash and NPK fertilizer gave the best performance on the growth and yield parameters of garden egg. Therefore, the integrated application of 10 t ha^{-1} of wood ash and 300 kg ha^{-1} of NPK fertilizer is recommended for improve garden egg growth and yield in Awka, Anambra State Nigeria.

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Regeneration of sectioned seeds of *Telfairia occidentalis* Hook F. (Fluted pumpkin)

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K E Y W O R D S

Telfairia,
Seed sections,
Emergence,
Propagules,
Minisetts,
Replications

A B S T R A C T

There is an acute shortage of Telfairia seeds during growing season, due to seed recalcitrance and the alternative uses to which the seeds are put. An experiment was conducted to determine the extent to which the seed of Telfairia occidentalis can be sectioned for the regeneration of propagules and to assess the growth response of the sectioned seeds. Pre-germinated seeds were sectioned into minisetts up to 32 per seeds. These were nursed for three (3) weeks and transplanted to the field in randomized complete block design with 3 replications. Whole seeds and seeds sectioned into two had the highest seedling emergence and reached their peaks at the end of 2 weeks after sowing. The least value of 30% seedling emergence was produced by seeds sectioned into 32. The vine growths of the whole seed (141 cm) and those sectioned into two (107 cm) were consistently and significantly higher than those of smaller seed sections that ranged from 16 - 84 cm. The relatively higher vigor expressed by whole seed over the sectioned seeds is probably due to the relatively higher food reserve in the former. The result obtained in this experiment has shown that it is possible to regenerate Telfairia occidentalis propagules by the use of seed sectioned up to 16. It is recommended that future studies should address the need to upgrade the seedlings emergence of sectioned seeds to achieve 100% survival in the nursery, and excellent plant stand in the field.

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INTRODUCTION

Telfairia occidentalis, Hook F (Fluted Pumpkin) belongs to the family *Cucurbitaceae*. It is a leaf and seed vegetable that is well known for its high nutritional, medicinal and economical potentials in the coastal area of West Africa. And it is widely consumed in the tropical region (Akoroda, 1990a,).

Telfairia occidentalis is a dioecious plant, although occasional monoecious plants have been reported by Akoroda (1990b). The female plants produces large leaves and seeds, while the leaves of the male is relatively small in size, the female plant in preferred with respect to leaf and seed production. (Akoroda, 1990a).

Young shoots and leaves of fluted pumpkin are cooked alone or in combination with other vegetables and used as potherbs or soups for different kinds of starchy dough. Fresh leaf concoction is a high value health tonic for the treatment of acute anemia (Schippers, 2000). The seed has been noted for their oil content (13%) and is use for cooking (Giami and Barber 2004). In spite of its importance, *Telfairia* seeds are always in short supply at planting time and this has been a limiting factor in its production. The biological disequilibrium caused by harvesting edible foliage from plant that could potentially bear fruit and the dioecious nature of the crop make sex ratio of the plant to affect the number of fruit bearing female (Akoroda, 1990b). There is increased interest in the utilization of the seed for other alternative uses such as, cooking and roasting of seed for consumption and substituting seed for egusi. These make the seeds to be highly limited and hence increase cost of seed. Farmers find it difficult to procure seeds for planting because of the high cost.

In order to ameliorate the problem of limited seeds available to produce seedlings required, Esiaba (1982) developed techniques where pre-germinated seeds were carefully split. Ojeifo and Ajekenrenbiaghan (2007) have reported the success attained in sectioning of seeds up to eight sections. Sectioning of seed aid in reducing the number of seed needed for propagation thereby reducing the cost of production for farmers. Hence the objectives of this study are to:

i. Determine the extent to which the seed of *Telfairia occidentalis* can be sectioned for the regeneration of propagules.

ii. Assess the growth response of the section seeds

MATERIALS AND METHODS

The experiment was carried out in the Teaching and Research Farm of Agronomy Department of Delta State University, Asaba Campus. The total area of the experimental plot was about $250m^2$ containing a total of 18 plots which were represented by raise beds with an area of 3m by 3m each. The fruits of *Telfairia occidentalis* were obtained from a local market. The fruits were carefully cut open with a knife for the extraction of the seeds. The extracted seeds were cured by spreading them out under a shade for 2 days to reduce microbial load. Thereafter, they were pre-germinated in sawdust to enable the easy opening up of the cotyledons. The pre-germinated seeds were separated into six seed lots. One was left whole, while the others were sectioned with the aid of a surgical blade while holding the seed with the aid of a forceps. The seeds where sectioned into two, four, eight, sixteen and thirty-two. Precaution was taken while sectioning the seeds into various sections, to ensure that each seed section had an embryonic content. However, this was more difficult to achieve with higher number of seed sectioning, particularly of those of 32 seed section. Sectioning the seeds in this study beyond sixteen seed sections to contain the embryo axis was not possible. Therefore, to obtain 32 seed sections from a seed, cutting each seed along the embryo axis was first made to get 16 seed sections subsequently, a perpendicular cut of each of the 16 seed sections was therefore made so that 16 had embryo axis while the other sixteen were without any embryo axis.

The propagules were thereafter treated with a mixed formulation of fungicide and insecticide (Imidadoprid 10%+Meta laxy10%+ carbendazim 10%) commercially called seed plus. Ten (10) gram of seed plus was mixed in 10 liters of water and the treated propagules were cured for about 3 hours before planting. The whole and sectioned seeds were nursed in a polythene bags containing equal proportion of sawdust and topsoil by volume. Watering was done on daily intervals by applying 20 ml and later increased to75 ml water per pot.

Germinated seedlings were transplanted from nursery to prepared field at 2 leaf stage with a planting space of 1m x 0.3m. Weeding was done at two weeks after planting. The creeping plants were raise from ground by staking them with erect bamboo stands and the vines where trained in a manner that enabled the collection of data.

A randomized complete block design replicated thrice was used for the treatments, namely whole seed and seeds sectioned into two, four, eight, sixteen and thirty-two parts. Variables observed during the course of the study were seedlings emergence, vine and root length at transplanting, and vine length in the field. These were measured with a meter rule. The number of leaves and branches were also counted manually and the plant girth was measured with veneer caliper.

Data collected were subjected to analysis of variance (ANOVA), and the treatment means were separated with least significant difference (LSD) at 5% level of probability.

RESULTS

Percentage Emergence

Seedling emergence of *Telferia occidentalis* started a week after planting in all the seed sections except that of seeds section into thirty-two. At two weeks after transplanting (WAT), the whole seed and seed sectioned into two had reached their peek of seedlings emergence (Table 1). Seedlings emergence of thirty-two seed sections started the second week after transplanting. At three weeks after sowing (WAS)), a sharp increase was observed across all the seed sections. The seedling emergence of whole seed and seed sectioned into two were significantly different from other seed sections at 5 weeks after transplanting

Possible limit of propagules regeneration from sectioned seed of *Telfairia occidentalis*

Table 2 shows the number of propagules that could be regenerated from one seed in the experiment carried out in the nursery, and shows the number of propagules that could be obtained assuming 100% survival of regeneration.

Table 1. Number and percentage (in parenthesis) of seedling emergence of whole and sectioned seed of *Telfairia occidentalis*.

	Weeks after Transplanting									
No of seed Section	**1**		**2**		**3**		**4**		**5**	
1	14	(70)	20	(100)	20	(100)	20	(100)	20	(100)
2	18	(90)	20	(100)	20	(100)	20	(100)	20	(100)
4	8	(40)	11	(55)	14	(70)	16	(80)	17	(85)
8	4	(20)	7	(35)	8	(40)	11	(55)	12	(60)
16	2	(10)	4	(20)	5	(25)	8	(40)	9	(45)
32	0	(0)	2	(10)	3	(15)	5	(25)	6	(30)
LSD($P<0.05$)	7.76		6.84		8.43		5.57		5.23	

Table 2. Propagules regenerated from sectioned seeds of *Telfairia occidentalis*

No. of seed Section	Number of plant from single seed assuming 100% regeneration	Regeneration from one seed In this study	Plant stand in the nursery (%)
1	1	1	100
2	2	2	100
4	4	3	75
8	8	4-5	50-60
16	16	5-6	30-40
32	32	6-10	20-30

Vine length at transplanting

Vine length at transplanting which were significantly different, was highest (41.67cm) for whole seed, followed by halved seed (30 cm), followed by quartered seed (20 cm), followed by those of seeds sectioned into eight (12.5 cm) and followed by those of seeds sectioned into sixteen (5 cm). This was however, similar to those of seeds sectioned into thirty two (4 cm). Fig (1)

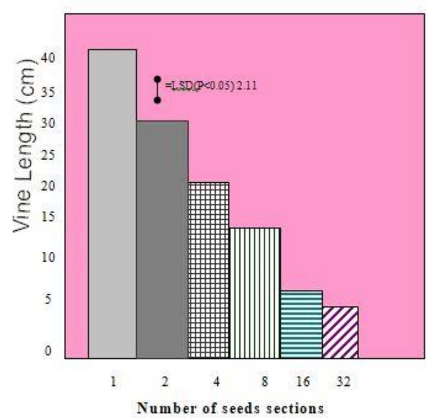
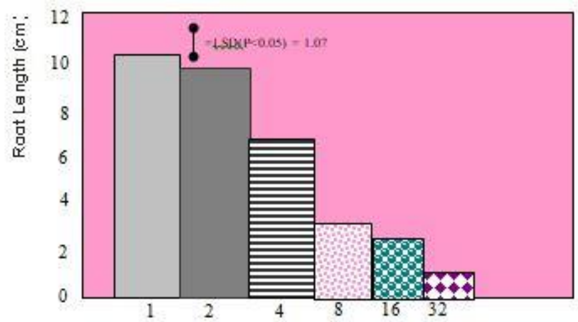


Fig 1. Vine length of *Telfairia occidentalis* at transplanting

Root length at transplanting

The root length of Tefairia was affected by the size of propagules. The root length declined drastically with reduction in the size of the propagules. Whole seed and seed sectioned into two had similar values of root length (10cm and 9.8cm respectively) which were significantly higher than the values produced by smaller propagules size of the sectioned seeds. The lowest values was produced by seed sectioned into sixteen and thirty-two per seeds and their value 2.33cm and 1.33cm respectively were also comparable (Fig 2).



Vine length of seedlings in the field

The vine length generally increased with time, irrespective of the size of the propagules. The vine lenght of the whole seed was consistently and significantly higher than those of the sectioned seeds (Table 3). These values significantly declined with the decline in the size of the propagules, and the least value was produced by the seed sectioned into thirty-two.

Table 3. Vine length of whole and sectioned seed of *Telfairia occidentalis*

	Weeks after Transplanting									
No of seed section	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1	60	79	98	122	141	155	175	198	211	226
2	40	54	24	94	107	120	141	163	193	204
4	28	36	47	64	84	93	115	126	133	149
8	21	28	36	39	49	56	69	78	96	104
16	13	17	33	27	34	41	57	64	72	84
32	6	8	9	14	16	21	25	30	36	40
LSD(P≤0.05)	2.7	4.1	3.5	5.4	7.3	6.8	8.2	7.2	6.9	6.3

Number of leaves

The number of leaves increased with time. The whole seed generally and significantly produced the highest number of leaves. This was followed by the seeds sectioned into two. The number of leaves generally declined with corresponding reduction in the size of the propagules. The least value was produced by seeds sectioned into thirty-two. During the early stage of plant growth, specifically from 1-4 WAS, comparable values were found between the seed sections. For example, the value of quartered seed and seeds sectioned into eight were comparable at 1 and 2 WAS. Similarly, a seed sectioned into 8 and 16 produced comparable values at 3 and 4 WAS, while seed sectioned into 16 and 32 produced comparable values at 1 WAS. From 5-10WAS, all the treatments produced significantly different values of numbers of leaves.

Table 4. Number of leaves of whole and sectioned seed of *Telfairia occidentalis*

	Weeks after sowing									
No of seed section	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1	26	35	46	59	70	87	102	131	150	150
2	21	32	42	54	63	78	107	119	135	135
4	16	22	30	39	45	57	81	93	108	108
8	14	20	25	31	38	49	68	77	89	89
16	10	16	22	28	34	43	60	68	78	78
32	7	11	16	19	22	28	41	49	57	57
LSD(P≤0.05)	3.1	2.5	3.2	7.1	3.4	4.7	4.4	4.8	3.1	4.3

Plant Girth

The plant girth had a slow increase with time from 1-10 WAP (Table 5). Like in the number of leaves, the plant girth declined with corresponding decline in propagules size. Whole seed produced the highest value of plant girth, while the seed sectioned into two had the least value.

Table 5. Plant Girth (cm) of whole and sectioned seeds of *Telfairia occidentalis*

	Weeks after sowing									
No of seed section	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1	1.0	1.1	1.1	1.2	1.2	1.2	1.3	1.3	1.4	1.6
2	0.9	0.9	1.0	1.1	1.1	1.1	1.2	1.2	1.3	1.4
4	0.8	0.8	0.9	0.9	0.9	0.9	1.0	1.1	1.1	1.2
8	0.7	0.8	0.8	0.8	0.8	0.8	0.9	0.9	1.0	1.1
16	0.6	0.6	0.7	0.7	0.7	0.8	0.8	0.8	0.9	1.1
32	0.5	0.5	0.6	0.6	0.5	0.6	0.6	0.6	0.7	0.9
LSD($P \leq 0.05$)	0	0	0.08	0.08	0.07	0.05	0.05	0.04	0.06	0.06

Number of branches

With regards to number of branches, whole seed produced the highest value (10.7) at 10 WAS which was closely followed by half seed (8.7) and the least value (3) was produce by seeds sectioned into thirty two. Thus, number of branches generally declined with corresponding reduction in the size of the propagules (Fig 3)

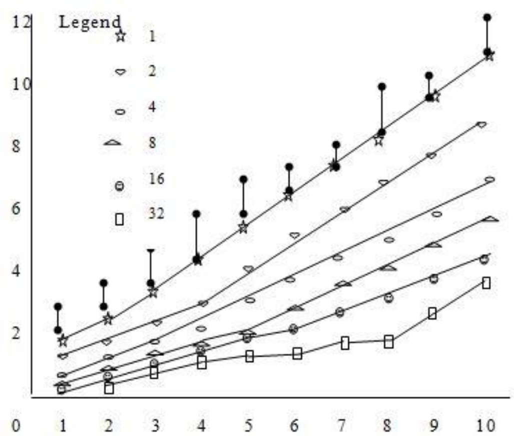


Fig 3. Number of branches of whole and sectioned seeds of *Telfairia occidentalis*

Adventitious root development

Adventitious root growth observed in the non-embryonic seed sections obtained from seed sectioned into thirty two. The propagules were nursed and observed for 5 weeks without germination. (Plate 1)

Plate 1

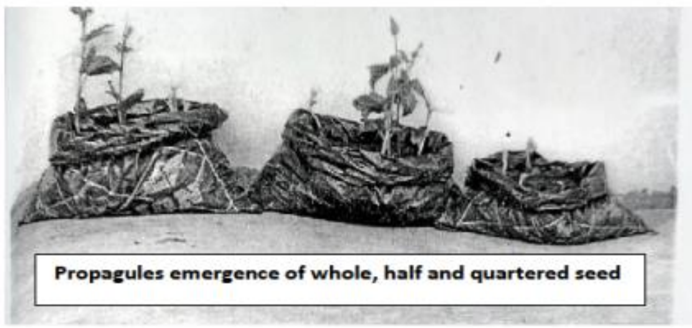


Plate 2

DISCUSSION

The result of this study has demonstrated the possibility of regenerating whole plant from sectioned seed of *Telfairia occidentalis*. This was true for seed sectioned up to sixteen Parts. This was due to the presence of polyembryony in *Telfairia occidentalis* as reported (Onovo *et al* 2009).

The relatively higher vigour expressed by whole seed and seeds sectioned into two over smaller seed sections, with regard to seedling emergence could be attributed to the relatively higher food reserve in the former propagules. This food reserve includes protein, carbohydrate, fats, minerals and vitamin which are basic resources for higher germination rate and seedling emergence. Akoroda and Adejoro (1990) reported that the cotyledonary food reserve of *Telfairia occidentalis* is a major factor of seed germination. The seedling emergence, vine length, number of leaves, number of branches and plant girth were strongly influenced by seed size. Ojeifo and Ajekenrenbiaghan (2007) reported a positive influence of seed size on the rate of seedling emergence, vine length, number of leave and plant girth.

There was similarities in the seedling emergence in number of leaves, number of branches, vine length and plant girth between whole seed and seed sectional but were significantly different from seed section. The vigour exhibited by whole seed and those sectioned into two could be attributed to the advantage of relative large food reserve in the whole seeds and seed sectioned into two. Esiaba (1983) reported that good food reserve enhanced early germination and growth. The least value in seedling emergence, vine length, number of leaves, number of branches as well as plant girth when compared to other seed sections were produced by Telfairia seed sectioned into 32 section. This is most probably due to its limited food reserve and limited portion of the embryo which resulted in relatively lower vigour. The food reserve enhance the development of vigorous roots at the early stage of growth to forage and provide nutrient for the plant where the seeds or propagules are depleted of food reserve for growth and development

CONCLUSION

The result obtained in this experiment has shown the possibility of regenerating *Telfairia occidentalis* propagules by the use of seeds sectioned up to sixteen having an embryonic section. It is possible to nurture such seedlings to maturity to produce economic yield if growth enhancement nutrient are applied.

Although seedling emergence declined with decrease in size of the seed sections, it is recommended that future studies should address the need to upgrade the seedling emergence of sectioned seeds to achieve 100% survival in the nursery.

RECOMMENDATION

The ability of *Telfairia occidentalis* to produce numerous plants from one seed could be enhanced by the use of large sized seeds, having large embryonic portion and with proper nursery management. The limitations observed in this study were poor growth which can be enhanced with the use of hormones and application of nutrient to beef up the vigour of the plant.

This can only be achieved through further research work. Tools for sex determination at seed and germination stages should be establishing to enable the elimination or salvaged for other purposes.

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Intercropping Impact on Weed Dry Matter, Soil C/N content and Sugarcane (*Saccharum officinarum*) Productivity

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K E Y W O R D S

Intercropping,
Plant crop,
Sugarcane,
Sugar quality,
Weed dry matter,

A B S T R A C T

The effects of intercropping on weed dry matter, soil C and N, and sugarcane productivity were investigated at Badeggi, Nigeria in 2016 and 2017. The results revealed that application of Sugarcane + Groundnut intercropping produced lower weed dry matter comparable to Sugarcane + Soybean intercropping which significantly increased growth and yield attributes of sugarcane. Application of Sugarcane + Groundnut intercropping, resulted in a comparable germination count, Tiller count, plant and stalk height with Soybean intercropping. It generated taller plants and stalks, more girth, brix content, millable cane, stools and cane yield. Similarly, Sugarcane + Groundnut intercropping and Soybean intercropping produced comparable stalk height and brix content. In conclusion, application of Sugarcane + Groundnut intercropping or Soybean intercropping effectively controlled weeds, increased Soil C and N, plant and stalk height, girth, brix content, millable cane, stools and cane yield of sugarcane.

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INTRODUCTION

Sugarcane (Saccharum officinarum) family (Poaceae) is widely grown crop in Nigeria. It provides employment to over a million people directly or indirectly besides contributing significantly to the national exchequer (FAOSTAT, 2019). It is widely grown in several tropical and subtropical countries of the world accounting approximately, 75 % of world's sucrose production from sugarcane (Wada *et al*., 2017). Besides the production of raw sugar, of which sugarcane is mainly produced for, sugarcane also represents an important source of renewable energy which has recently gained attention because of ethanol production (Priyanka *et al*., 2019). In Nigeria, it is grown on an estimated land area of over 500, 000 hectares with a yield potential of over three million metric tons of sugarcane (Bassey *et al*., 2021). The gap between domestic production and the demand for sugar can be attributed to many factors. This include rapidly increasing population, increased demand for food, limited scope for extension of cultivation to new areas, diversified low yield potential, food scarcity, heavy importation and not self – sufficient in sugar production. The conventional cropping systems are exhaustive and depleting the soil badly, cultivable lands is decreasing due to urbanization and industrialization, enlarged families, and the current system of monocropping is not able to keep pace with increasing demands of farmers due low yield and subsistence farming is alarming (Geetha *et al*., 2015; Mohammed *et al*., 2017).

One potential way to improve sugarcane production among small land holders and meet demand for sugar is by sugarcane intercropping. Sugarcane is a long duration and widely spaced crop in comparison with other field crops; it offers a great scope for using its interspaces by growing short duration crops. In general, sugarcane has a juvenile period of 100-120 days, which can accommodate intercrops of arable crop and can be widely practiced (Rasool *et al*. 2011and Geetha *et al*. (2015).The wide space (1 – 1.5 m) available between two rows of sugarcane, long duration for sprouting (21–30 days), initially slow rate of growth and its ability to compensate for any loss of tillers due to intercropping, has helped successful intercropping of cereals, legumes, vegetables and spices in plant and ratoon crop (Priyanka *et al*., 2019).Sugarcane intercropping can be efficient and economically viable in increasing production per unit area and ensure judicious use of resources with increase in farmer's economy. For example in Egypt, intercropping sugarcane with soybean significantly increase sugarcane yield and sugar quality (Morsy *et al* .2017). In India, Singh *et al*. (2017) reported significant yield increase when Potatoes was intercropped with sugarcane. In Nigeria, intercropping sugarcane with arable crops has been recommended for optimum sugarcane production (Gana, 2013). In Nigeria, research information on industrial sugarcane when intercropped with arable crops is scarce. Hence, the objectives of this study were to evaluate the effects of industrial sugarcane intercropping on weed dry matter, sugar quality, net farm income and sugarcane productivity.

MATERIALS AND METHODS

A field trial was conducted at the upland sugarcane experimental field of National Cereals Research Institute, Badeggi (Lat. 90 45' N, Long. 60 07' E and 89 m above sea level) in the southern Guinea savanna agro-ecological zone of Nigeria in 2016 and 2017 wet and dry season. The total rainfall during the experimental period was 1504.1 mm in 2016 and 1045.4 mm in 2017 while the mean air temperature was 35 to 38 oC in 2016 and 34 to 36 oC in 2017. Composite soil samples were taken before field establishment from ten spots along a diagonal and at harvest from each treatment plot from 0 to 15 cm depth, and subjected to routine analyses. Particle size analysis was done by the Bouyoucos hydrometer method (Gee and Or 2002). Soil organic carbon was determined by the procedure of Walkley and Black using the dichromate wet oxidation method (Nelson *et al*. 1996). Total N was determined by the micro—Kjeldahl digestion method (Bremner and Mulvaney 1982). The Olsen method was used to determine available phosphorus, and flame photometry for exchangeable potassium (Okalebo *et al*. 2002). Soil pH was determined in 1:2 soil–water ratio using digital electronic pH meter.

Before cultivation, the vegetative cover of the experimental site was manually cleared, ploughed and harrowed with a tractor. Thereafter, the land was marked out into plots with bunds at the edges for water retention. Gross plot size was 6 x 5 m (30 m2) consisting of 5 sugarcane rows, and four rows of component crops, while net plot size was 5 x 3 m (15 m2).Sugarcane was planted at 1.5 m inter – row spacing a month before the component species were planted in between at 0.75 m inter – row spacing. Tender healthy young stalks of six months old sugarcane were used as planting material. The stalks were cut into setts each containing three eye buds, planted continuously end-to-end without intra-row spacing in shallow sunken bed. The NPK fertilizer was applied at150 kg N, 60 kg P2O5 and 90 kg K2 O in equal halves at planting and 10 WAP. Rainfall was supplemented with irrigation in May which was the establishment of the rainy season. The treatments consisted of Short kaura, Beniseed, Soybean and Groundnut were intercropped with sugarcane along with sole sugarcane arranged in a randomized complete block design with three replications. Weed species samples in each plot were collected froma1x 1m2quadrat at 3, 6 and 9 months after planting (MAP). Weed species seedlings in each quadrat were clipped at the soil level and identified according to Akobundu *et al*. (2016). The weed samples were oven dried at 800 C to a constant weight and weighed to determine the dry matter in g per m2. Sugarcane germination (%) was taken by counting the number of sprouted buds per plot at three weeks after planting and expressed as follows:

$$\text{Germination percentage} = \frac{Number of sprouted buds per net plot}{Total number of buds on the setts planted per plot} \times 100$$

Number of tillers per plot was taken by counting the number of axillary tillers per plot at two months after planting. Plant height was measured using meter rule from the base of the plant to the top of the uppermost leaf at 3 and 6 MAP and expressed in centimeters. Stalk height was measured using meter rule from the base of the plant to the uppermost node at 6, 9 and 12 MAP and expressed in centimeters. Stalk girth was measured using Vernier caliper from the middle of the plant at 8, 10 and 12 MAP and expressed in centimeters. Percent brix was measured using hand refractormeter from the base of the plant at 9 and 12 MAP to determine the level of soluble sugar. Number of sugarcane stools per plot was taken by counting the number of stools at 12 MAP or months after ratooning (MAR). Number of millable stalk per stool was taken by counting the number of stalks at 12 MAP or months after ratooning (MAR). Stalk (Cane) yield at harvest was taken from the harvested stalks in the net plot, tied into bundles and weighed (tons ha-1). All data collected were subjected to analysis of variance (ANOVA). The means were separated using Duncan Multiple Range Test at 5% level of probability using SAS version 9.0 statistical package.

RESULTS

The soil was sandy loam in texture with soil pH moderately acidic. In general, the soils were low in nitrogen, phosphorus and other essential nutrients (Table 1). Weed dry weight was significantly ($P < 0.05$)lower in Sugarcane + Groundnut intercropping at 3 and 6 MAP in 2016, and Sugarcane + Soybean intercropping had lower weed dry weight only at 6 MAP than the other treatments (Table 2). Germination count (%) was significantly ($P < 0.05$) different between the sugarcane intercrops in both year of study (Table 3). Sugarcane + Groundnut intercropping had significantly higher germination percentage than the other intercrops in each year of study (Table 3). Furthermore, Sugarcane + Groundnut intercropping produced more tillers than the other intercrops in each year of study (Table 3). Taller sugarcane were obtained in Sugarcane + Groundnut intercropping than the other intercrops in each year of study

(Table 3). Stalk height and internode length were significantly ($P < 0.05$) different between the sugarcane intercrops in both year of study (Table 3). Sugarcane + Groundnut intercropping had consistently higher soil C and N than other intercrops in both years of study (Table 3). Thicker sugarcane was recorded in Sugarcane + Groundnut intercropping compared with that in other intercrops in both years of study (Table 4). Furthermore, higher brix content was obtained in Sugarcane + Groundnut intercropping compared with that in other intercrops in both years of study (Table 4). Millable canes and Stools were significantly ($P < 0.05$) different between the sugarcane intercrops in both year of study (Table 4). Sugarcane + Groundnut intercropping consistently produced more millable canes and stools other intercrops in both years of study (Table 4). Cane yield of sugarcane was significantly higher in Sugarcane + Groundnut intercropping compared with the other intercrops in both years of study (Table 4). Similarly, Sugarcane + Groundnut intercropping consistently produced higher net farm income than the other intercrops in both year of study (Table 4).

Table 1: Initial soil physical and chemical properties in at Badeggi in 2016

Soil properties	Value
Sand (g kg^{-1})	722
Silt (g kg^{-1})	135
Clay (g kg^{-1})	143
Textural class	Sandy loam
pH (H_2O) (g kg^{-1})	5.80
Organic Carbon (g kg^{-1})	2.37
Total Nitrogen (g kg^{-1})	0.06
Available Phosphorus(mg kg^{-1})	20.29
Ca++ (cmol kg^{-1})	2.48
Mg++ (cmol kg^{-1})	1.38
K+ (cmol kg^{-1})	0.16
Na+ (cmol kg^{-1})	0.09
Exchangeable acidity(cmol kg^{-1})	1.03
ECEC (cmol kg^{-1})	5.14

Analyzed at National Cereals Research Institute Laboratory

Table 2: Sugarcane intercropping effects on weed dry weight (g m^{-2})

Treatments	**Weed dry weight (g m-2)**					
	3 MAP		**6 MAP**		**9 MAP**	
	2016	**2017**	**2016**	**2017**	**2016**	**2017**
Sugarcane Sole	0.68	0.60	0.58	0.50	0.47	0.41
Sugarcane + Short kaura	0.64	0.63	0.52	0.51	0.33	0.38
Sugarcane + Beniseed	0.71	0.63	0.62	0.54	0.39	0.42
Sugarcane + Soybean	0.62	0.60	0.51	0.51	0.20	0.20
Sugarcane + Groundnut	0.61	0.63	0.53	0.48	0.33	0.33
LSD (0.05)	0.1	0.1	0.2	0.1	0.2	0.1

MAP – Months after planting, LSD – Least significant difference

Table 3: Sugarcane intercropping effects on some growth parameters of sugarcane

Treatments	**Germination count (%)**		**Tiller count/ plot**		**Plant height (cm)**		**Stalk height (cm)**		**Soil C (g kg-1)**		**Soil N (g kg-1)**	
	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
Sugarcane + Sole	53.8	66.7	36.5	49.3	150.4	176.4	119.9	150.2	2.41	3.23	0.12	0.17
Sugarcane + Short kaura	50.5	67	35.8	47.7	144.8	184.5	118.6	155.3	2.44	3.36	0.15	0.19
Sugarcane + Beniseed	50.9	70.3	36.3	58.7	141.7	176.1	119.5	160.2	2.45	3.37	0.15	0.18
Sugarcane + Soybean	54	72	39.3	64.7	154.2	190.6	127.4	166.9	2.47	3.39	0.16	0.19
Sugarcane + Groundnut	59	83.3	43.2	67	164.8	198.3	136.3	175.5	2.51	3.45	0.19	0.24
LSD (0.05)	5.8	5.2	6.5	3.9	15	4.4	14.8	3.4	0.02	0.01	0.01	0.02

LSD – Least significant difference

Table 3:

Treatments	Germination count (%)		Tiller count/ plot		Plant height (cm)		Stalk height (cm)		Soil C (g kg^{-1})		Soil N (g kg^{-1})	
	2016	**2017**	**2016**	**2017**	**2016**	**2017**	**2016**	**2017**	**2016**	**2017**	**2016**	**2017**
Sugarcane + Sole	53.8	66.7	36.5	49.3	150.4	176.4	119.9	150.2	2.41	3.23	0.12	0.17
Sugarcane + Short kaura	50.5	67.0	35.8	47.7	144.8	184.5	118.6	155.3	2.44	3.36	0.15	0.19
Sugarcane + Beniseed	50.9	70.3	36.3	58.7	141.7	176.1	119.5	160.2	2.45	3.37	0.15	0.18
Sugarcane + Soybean	54.0	72.0	39.3	64.7	154.2	190.6	127.4	166.9	2.47	3.39	0.16	0.19
Sugarcane + Groundnut	59.0	83.3	43.2	67.0	164.8	198.3	136.3	175.5	2.51	3.45	0.19	0.24
LSD (0.05)	5.8	5.2	6.5	3.9	15.0	4.4	14.8	3.4	0.02	o.o1	0.01	0.02

Sugarcane intercropping effects on some growth parameters of sugarcane

LSD – Least significant difference

Table 4: Sugarcane intercropping effects on some yield parameters of sugarcane

Treatments	Stalk girth (cm)		Brix (%)		Millable cane/ Plot		Stools/Plot		Cane yield (t ha-1)		Net farm income (Naira ha-1)	
	2016	**2017**	**2016**	**2017**	**2016**	**2017**	**2016**	**2017**	**2016**	**2017**	**2016**	**2017**
Sugarcane + Sole	3.1	2.7	14.9	18.1	73.9	94.7	15.9	14.3	66.1	59.9	2577	3204.7
Sugarcane + Short kaura	2.9	2.7	14.5	18.2	71.5	94.9	17.6	15.3	71.7	66.4	5493	5750
Sugarcane + Beniseed	3.2	2.8	15.5	19.2	80	98.7	16.7	17	72.1	74.2	4220	8462
Sugarcane + Soybean	3.1	2.9	15.8	20.4	83.7	100	17.2	16.6	81.3	77.2	9280	9758.1
Sugarcane + Groundnut	3.5	3.5	18.9	21	90.5	119.1	19.7	20	87.6	85.8	16347	13261.3
LSD (0.05)	0.3	0.2	1.2	0.4	2.5	2.4	3.5	1.8	12.8	0.9	6401.8	1269.7

LSD – Least significant difference

DISCUSSION

The low nutrient status of initial soil physical and chemical properties of the experimental site could be attributed to long time cultivation of the field with frequent usage of inorganic fertilizers which could help in soil improvement. Gana (2013) reported that nutrient budget for sub – Saharan Africa shows a net annual depletion of N, P, and K as a result of long term cropping with little or no inputs due to leaching and erosion. The author therefore recommended the recycling of organic residues as means of improving soil productive capacity and reducing dependence on mineral fertilizer. The reduction in weed dry weighty caused by Groundnut and Soybean intercropping could be due to coverage which interferes with weed seeds germination, mainly due to changes in moisture, light and soil temperature, which are main controllers of seed dormancy and germination. This in turn affects seedling development by acting as a physical barrier, causing etiolation and weak stems, making them more prone to mechanical damage/lodging. Furthermore, chemical issues may arise from changes in the C/N ratio and allelopathy, as well as creating favorable environment for insects and microorganisms, which can either host on weeds or feed from seeds. This confirms the findings of Martin-Guay *et al*.(2018) and Bassey *et al*. (2019a and b), who found, significant variation among cereal/legume intercropping to reduction in weed dry matter. The high germination percentage, tiller count, plant and stalk height obtained from sugarcane intercropped with legume may be attributed to the nitrogen supplied by the legume component crop (Groundnut) through nitrogen fixation and mineralization of the decomposed incorporated herbage. Gana (2013) reported beneficial effects of legumes on sugarcane growth parameters (Germination count, tiller, stalk height and internode length) from incorporated legumes at Badeggi in Nigeria. Soil organic carbon (SOC) and soil total nitrogen (STN) were increased by Groundnut and Soybean intercropping. This can be attributed to the high C/N ratio of the legume residue which ensures a slow rate of mineralization of the residue, with consequent increase in SOC. The significant effects of intercropping legumes on SOC and STN might be due to dead leaves and roots added to the soil. The immobilization of N as a result of the high C/N ratio of the residues could be responsible for the high STN. Our finding was in agreement with those of Bassey *et al*. (2019b and), who noted an appreciable increase in soil fertility in crop mixture, involving certain tropical legumes after cropping. They adduced the increase in soil fertility to the ability of legumes to fix large quantities of nitrogen into the soil. The positive response (increase) observed in this study for stalk girth, brix content, millable canes, number of stools and cane yield due to sugarcane intercropped with groundnut could probably be attributed to incorporation of residues resulting in high SOC. Increase in soil organic matter level might have resulted in increase in soil microbial activity, soil fertility, nutrient supply, porosity, permeability and thus, soil productivity (Yusuf *et al*., 2009; Bassey *et al*., 2019c). The findings obtained are consistent with that of other workers in the same savanna agroecological zone of Nigeria (Afolabi *et al*., 2017). The high yield obtained in the study area might be attributed to adequate moisture and other optimum growth factors obtained in this study (Mohammed *et al*., 2017). The study has shown that the application of Groundnut or Soybean as intercrops for sugarcane effectively controlled weeds, increased soil C and N, growth and cane yield of sugarcane in this agroecology of Nigeria.

CONCLUSION AND RECOMMENDATION

The study has shown that the application of Groundnut or Soybean as intercrops for sugarcane effectively controlled weeds, increased soil C and N, growth and cane yield of sugarcane in this agroecology of Nigeria. Based on the findings of this research, Groundnut or Soybean as intercrops should be used for effective weed control, increased soil C /N, growth and cane yield of sugarcane.

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Impacts of Selected Plant Extracts on Three Solanacea Cultivars Nursery Development

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K E Y W O R D S

Biofertilizer,
Biostimulants,
Nursery,
Phytochemicals,
Solanaceae

A B S T R A C T

A trial was carried out at the nursery unit, Faculty of Agriculture, Nnamdi Azikiwe University, Awka to evaluate the impacts of three plant extracts(Siam, Bitter leaf and Moringa) on the growth parameters and biomass of three solanacea nursery crops(tomato, garden egg and pepper).The Randomized completely block design experiment was replicated three times. Despite crop type, moringa extract significantly enhanced early germination and emergence % of all the tested crops, Throughout the course of the work bitter leaf extract produced the biggest fresh and dry bio masses, tomato(28.13g and 3.37g), pepper(84.10g and 10,0g) and garden egg(50.10g and 6.10g).Bitter leaf extract also produced the tallest plants followed by moringa extract. While leaf area of the tested crops were significantly improved by the extracts, leaf number seemed to be controlled genetically. Plant extracts contain bio stimulants, bio pesticides, hormones, vitamins and minerals that can promote plant growth and increase plant response on stress .Generally, these plant extracts are readily available, cheap and easy to prepare and apply. We therefore recommend the use of these extracts in raising nursery crops and growing crops in the field especially bitter leaf and moringa extracts which are environmentally friendly and sustainable.

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INTRODUCTION

The Solanaceae family is a monophyletic dicot group, which contains widely cultivated crops with individual species serving as a food source, as a source of bioactive molecules or as ornamentals (Gebhardt,2016).Species belonging to this family, such as the African garden (*Solanum macrocapon* L) egg potato (*Solanum tuberosum*), tomato (*Solanum lycopersicum*), pepper (*Caspicum annuum*) or tobacco (*Nicotiana tabacum*), are grown on all continents with temperate or tropical climates and are commonly found in many households worldwide. They are grown mainly as vegetables which are important components of daily diets in Africa and important sources of income, especially in urban and sub-urban areas. Garden egg, also known as African eggplant (*Solanum melongena*), is one of the most important vegetable crops in Nigeria and in West Africa (Onwusah-Ansah *et al*, 2001). Garden egg is not only consumed almost on daily basis by rural and urban families but it also represents the main source of income for many rural households in the forest zone of the country, (Danquah-Jories, 2001).The crop is grown for either the immature fruits or leaves depending on the locality. The immature fruits are either eaten raw or cooked. Tomato is a very widely used and important vegetable in Nigeria, about 25,000 tones of fresh tomato are produced annually. It is grown for its fruit and is used in varieties of ways for the production of puree pastes, juices, and canned fruit or mixed in chilli sauces. Pepper is a vital commercial crop, cultivated for vegetable, spice, and value-added processed products (Onwusah –Ansah *et al*, 2001). Besides vitamins A and C, the fruits contain mixtures of antioxidants notably carotenoids, ascorbic acid, flavanoids and polyphenols (Okolie *et al*., 2022). This makes it a very important constituent of many foods, adding flavour, colour and pungency and, hence, an important source of nutrition for humans. Peppers can be used whole, chopped or in various processed forms such as fresh, dried and ground into powder (with or without the seeds), or as an extract .

Solanaceae family crops like pepper, garden egg and tomato are normally raised in nursery due to the small size of their seeds which produce weak seedlings when they germinate. A nursery is a place where young plants are raised under intensive management for later transplanting into the field (Onwusah –Ansah *et al*, 2001).. Many horticultural crops can be grown in-situ but, experience has shown that raising seedlings in the nursery has a number of advantages especially Economy of propagules, (Peter, 2007). Nursery practices also enable intensive care for the seedlings – protection against animals, diseases, insects and rodents, regular maintenance practices, watering / irrigation and manuring. The dependency on the use of inorganic fertiliziers as a source of plant nutrients by farmers and their high cost is further associated with land and soil degradation and environmental pollution calls for alternative safe natural sources of plant nutrients (Onwusah –Ansah *et al*, 2001).. Also the application of fertilizer in nursery crops always pose some toxicity challenges. (Du Jardin, 2012). This is why this research work focused on the use of plant extracts which modern researchers have discovered to possess bio-stimulant, bio-fertilizer and bio-pesticide abilities. *Moringa oleifera, Chromoleana odorata and Vernonia amagdalina*extracts were used for the experiment as sources of nutrients.

MATERIALS AND METHODS

Experimental Materials:The Horticultural seeds (pepper seeds (NIHORT 47-4), garden egg seeds (Local best) and tomato seeds(Platinium)were bought from Rumuodomaya market in Obio/Akpo LGA of Rivers State.The plant extracts from (*Vernonia amygdalina* (Bitter leaf*), Chromolaena odorata (*Siam) *and Moringa oleifera (*Moringa)) were collected from nearby farms in Nnamdi Azikiwe University, Awka,

Experimental Materials Preparation: About 60 grams of bitter leaf ,moringa and siam leaves were each macerated in 120 ml of clean water and the crude extract was filtered and applied at equivalent of 10m/m^2 (Fabunmi and Awe,2019).The extracts served as sources of plant nutrients, growth hormones and biostimulants (phytochemicals). Except for the control plots, the extracts were applied in the Nursery trays soil a day before planting in order to check their impact on seed germination and emergence. Nursery trays were used for planting and river sand as planting medium.

Experimental Layout: The 3x3 complete randomized design experiments was replicated 3 times. Each seed tray contained 10x20 (200) holes and was divided into 3 partitions for the three test crops and 2 seeds were planted in each hole.

Data Collection Techniques: Percentage emergence was taking at 5,6 and 7 DAP(Days After Planting),plant height(cm) and leaf area(cm^2) were taking at 12,16,20,24 and 28 DAP with a flexible meter rule. Leaf area were estimated for the three crops(Mohammed and Krishnamurthy,2001).Number of leaves were counted manually while biomass were taking with Electronic weighing machine at the end of 32DAP.

Data Analysis: Data collected were subjected to statistical analysis using Genstat 12 editon. Data were subjected to ANOVA test and differences between means were determined at the 5% level of probability using Duncan's multiple range test.

RESULTS

Impact of plant extracts on the crops seed emergence (%)

Moringa leaf extract enhanced 50% emergence at 5 DAP. Emergence started from 6 DAPS in other extracts, on 7DAP virtually all the seeds have emerged in all the treatments (Table 1).

Table 1. Impact of plant extracts on the crops seed emergence (%)

	Days After Planting								
	5			6			7		
Plant extract	tomato	Garden egg	pepper	Tomato	Garden egg	pepper	tomato	Garden egg	pepper
Control	0	0	0	75	80	0	90	85	90
Siam	0	0	0	80	85	80	90	90	90
Moringa	50	50	30	90	90	85	95	95	95
Bitter leaf	0	0	0	85	85	85	95	90	95

Impact of plant extracts on nursery tomato plant height (cm)

Bitter leaf extract produced the highest plant height up till 20 DAP after planting, while moringa leaf extract took over from 24 to 28 DAP. The control had the least height. (Table 2).

Table.2. Impact of plant extracts on nursery tomato plant height (cm)

.Extracts	12 DAP	16 DAP	20 DAP	24 DAP	28 DAP
Control	2.067a	2.067a	2.50a	2.80a	3.0a
Siam	2.033a	2.033a	2.60a	3.70b	4.03b
Moringa	2.667b	2.607b	3.367b	4.60d	4.967d
Bitter leaf	2.867c	2.867b	3.40b	4.10c	4.40c
LSD	0.27	0.2766	0.22	0.35	0.354

Impact of plant extracts on nursery tomato plant height (cm).

Moringa leaf extract produced the tallest plant height at 28 DAP(4.9cm), followed by bitter leaf leaf extract (4.36cm). The control had the least height. (Table 3)

Table.3. Impact of plant extracts on garden egg nursery plant height (cm)

Extracts	12 DAP	16 DAP	20 DAP	24 DAP	8 DAP
Control	1.63a	2.50a	2.67a	2.83a	3.13a
Siam	2.30b	2.63a	3.30b	3.70b	4.03b
Moringa	2.27b	3.50b	3.670c	4.53d	4.96d
Bitter leaf	2.23b	3.40b	3.90b	4.13c	4.36c
LSD	0.764	0.22	0.448	0.41	0.50

Impact of plant extracts on nursery pepper plant height (cm).

Bitter leaf extract produced the highest plant height up till 28 DAP(3.5cm), followed by moringa leaf extract (3.4cm). The control had the least height. (Table 4.)

Table 4. Impact of plant extracts on nursery pepper plant height (cm)

Extracts	12 DAP	16 DAP	20 DAP	24 DAP	28 DAP
Control	0.967a	1.13a	1.60a	1.83a	2.16a
Siam	1.633a	2.033a	2.20a	3.00b	3.16b
Moringa	1.07b	1.53b	2.50b	3.20d	3.40d
Bitter leaf	1.86c	2.06b	2.53b	3.33c	3.50c
LSD	0.33	0.163	0.326	0.40	0.34

Impact of plant extracts on nursery tomato number of leaves.

Table 5. showed that the extracts had no effect on 16 DAP, moringa extract produced the highest number of leaves on 20,24 and 28 DAP followed by bitter leaf.

Table 5. Impact of plant extracts on nursery tomato number of leaves.

Extracts	16 DAP	20 DAP	24 DAP	28 DAP
Control	3	3a	4a	4.33a
Siam	3	3a	6c	6.0b
Moringa	3	4b	8d	8.0c
Bitter leaf	3	3.3a	5.33b	7.67c
LSD	-	0.57	0.57	0.75

Impact of plant extracts on nursery pepper number of leaves

Table 6. showed that the extracts had no effect on the tested crops leaf number till 24DAP,whensiam extract had the highest (3.67) At 28 DAP all the extracts had the same number of leaves except in control.

Table 6 Impact of plant extracts on garden egg nursery number of leaves.

Extract	16 DAP	20 DAP	24 DAP	28 DAP
Control	1.63a	3a	3a	3a
Siam	2.3a	3a	3.67b	4b
Moringa	2.27a	3a	3.33a	4b
Bitter leaf	2.23a	3a	3.0a	4b
LSD	-	-	0.3	0.3

Impact of plant extracts on nursery pepper number of leaves

Table 7 showed that the extracts had no effect on 16 DAP, moringa extract produced the highest number of leaves in 20,24 and 28 DAP followed by bitter leaf. Control was the least followed by siam extract.

Table 7. Impact of plant extracts on nursery pepper number of leaves

Extract	16 DAP	20 DAP	24 DAP	28 DAP
Control	3	3a	4a	4.33a
Siam	3	3a	6c	6.0b
Moringa	3	4b	8d	8.0c
Bitter leaf	3	3.3a	5.33b	7.67c
LSD	-	0.57	0.57	0.75

Impact of plant extracts on nursery tomato leaf area (cm^2)

Other than control, the extracts had the same significant effect on tomato leaf area on 16 DAP. On 28DAP moringa(8.0 cm^2) had the highest followed by bitter leaf (7.67 cm^2)and control (4.33 cm^2)was the least in Table 8.

Table 8. Impact of plant extracts on nursery tomato leaf area (cm^2)

Extract	16 DAP	20 DAP	24 DAP	28 DAP
Control	0.68a	0.757a	0.88a	4.33a
Siam	0.91b	0.95b	1.63c	6.0b
Moringa	0.86b	1.10c	1.55b	8.0d
Bitter leaf	0.86b	1.28d	2.06d	7.67c
LSD	0.048	0.0415	0.0268	0.75

Impact of plant extracts on garden egg nursery leaf area (cm^2).

The siam leaf extract produced the largest leaf area throughout the course of the work followed by moringa extract while the control was the least inTable 9.

Table 9. Impact of plant extracts on garden egg nursery leaf area (cm^2)

Extract	16 DAP	20 DAP	24 DAP	28 DAP
Control	1.54a	1.59a	1.63a	1.65a
Siam	1.54a	1.87b	2.75c	2.78d
Moringa	1.64a	1.75c	2.28b	2.44c
Bitter leaf	1.54	1.64d	1.87d	1.99b
LSD	0.011	0.017	0.045	0.012

Impact of plant extracts on nursery pepper leaf area (cm^2)

The bitter leaf extract produced the largest leaf area throughout the course of the work followed by siam extract while the control was the least.Table.10.

Table10. Impact of plant extracts on nursery pepper leaf area (cm^2)

Extract	16 DAP	20 DAP	24 DAP	28 DAP
Control	0.24a	0.45a	0.75a	0.98a
Siam	0.35b	0.93b	1.17c	1.38b
Moringa	0.40b	0.79c	1.04b	1.35d
Bitter leaf	0.44c	0.98d	1.31d	1.41c
LSD	0.048	0.028	0.0368	0.228

Impact of plant extracts on crops biomass (g).

Bitter leaf extract had the highest biomass (28.13g) on tomato plants, while siam leaf extract and moringa leaf extract had same biomass but significantly higher than control which was the least. The dry weight followed the same trend(Table 11).Bitter leaf extract also had the highest biomass(84.10g) on pepper plant, while siam leaf extract and moringa leaf extract had same biomass but significantly higher than control (14.10g)which was the least. The dry weight followed the same trend.Bitter leaf extract still had the highest biomass (50.10g) on garden egg plants, followed by moringa leaf extract. The control (20.10g) was the least. The dry weight followed the same trend (Table.11).

Table 11.The Impact of plant extracts on crops biomass (g).

	Weight wet			Dry weight		
Plant extract	**Tomato (40seedlings**	**Garden egg (50 seedlings)**	**Pepper (70 seedlings)**	**Tomato (40 seedlings)**	**Garden egg (50 seedlings)**	**(pepper) (70 seedlings)**
Control	8.10a	20.10a	14.10a	0.97a	2.417a	1.69a
Siam	24.10b	45.10b	49.10b	2.89a	5.317b	5.68a
Moringa	24.10b	46.267c	50.10b	2.87a	5.423c	5.88a
Bitter leaf	28.13c	50.10d	84.10c	3.37d	6.10d	10.06d
LSD	0.0576	0.28	0.006	0.0057	0.0835	0.11

DISCUSSION

The Impacts of three crude plant extracts from moringa,siam and bitter leaf were tested on the growth parameters of three solanacea nurserycrops viz pepper,garden egg and tomato. Moringa leaves are potential source of vitamin A and C, iron, calcium, riboflavin, b-carotene, phenolics (Brown and Saa,2015) The effect of moringa leaf extract is analogous to synthetic hormonal effect because the extract contains zeatin, a purine adenine derivative of plant hormone group cytokines (Brown and Saa,2015).This hormones and other bio stimulants aid in seed germination and emergence. This result is in accordance with the work of Ana and Chaves (2019).

Throughout the course of the work bitter leaf extract poduced the biggest wet and dry bio masses, for tomato(28.13g and 3.37g),for pepper(84.10g and 10,0g) for garden egg(50.10g and 6.10g).Bitter leaf extract also produced the tallest plants followed by moringa extract.While leaf of the tested crops were significantly improved by the extracts leaf number seemed to be controlled genetically.Moringa leaves sampled from various parts of the world were found to have high zeatin concentrations of between 5 μg and 200 μg/g of leaves (Fuglie, 2000). Moringa leaf extract when sprayed onto leaves of onions, bell pepper, soyabeans, sorghum, coffee, tea, chilli, melon and maize was shown to increase yields of these crops (,Abd El-Mageed,*et al*.,2017). Phytochemical screening of siam (Usunobun and Okolie, 2016) showed the presence of flavonoids, saponins, alkaloids, tannins etc. Mineral analysis showed the richness of *Chromolaena odorata* leaves in calcium (487.40mg/100g), sodium (44.22mg/100g), potassium (96.91mg/100g), magnesium (116.70mg/100g), zinc (3.77mg/100g), iron (67.71mg/100g), phosphate (143.15mg/100g), (Usunobun and Okolie,2016). Bitter leaf contains different bioactive compounds including; flavonoids, saponins, alkaloids, tannins, phenolics, terpenes, steroidal glycosides, triterpenoids, and hormones [Quasie *et al*., 2016; Luo *et al*., 2017] and is also rich in Vitamin A, Vitamin C, Vitamin E, Vitamin B_1, and Vitamin B_2 and minerals (Okolie,*et al*.,2022).Plant extracts contain biostimulants, biopesticides, homones, vitamins and minerals that can promote plant growth (Adenuga *et al*.,2010)and increase plant response on stress (Du Jardin, 2012),.Generally,,these plant extracts are readily available, cheap and easy to prepare and apply. We therefore recommend the use of these extracts in raising nursery crops and growing crops in the field especially bitter leaf and moringa extracts which are environmentally friendly and sustainable.

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Productivity of Sweet Potato (*Ipomoea batatas* (L.) Lam.) Cultivars in Ibadan, Nigeria

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ABSTRACT

A field experiment was conducted to evaluate the productivity of 20 sweet potato (Ipomoea batatas (L.) Lam.) cultivars in Ibadan, Nigeria. The cultivars evaluated were obtained from the Department of Agronomy sweet potato germplasm multiplication field and were planted 30cm apart on the crest of ridges 3m long in a randomized block complete design (RCBD) with four replications. Observation and data were collected on number of leaves, main vines length, percentage survival, percentage ground cover, number of tubers per plant, fresh root and shoot yield. Result showed that there were significant differences (P < 0.05) among the cultivars evaluated. The number of leaves produced by the cultivars ranged from 109 to 205. Cultivar Eruwa-cream produced the highest number of leaves, while cv 'Barth' had the least at 12 WAP. Mean length of the main vine ranged from 84.69cm (cv TIS 86/0356) to 231.54cm (cv 440293). Percentage survival and percentage ground cover ranges from 80.0% (cv V005) to 100.0% (cv TIS 86/0356) and 25.3% (cv V003) to 79.0% (cv V084) at 10 WAP respectively. Maximum number of tubers (3.45/plant) was produced by cultivar 199034.1; this was significantly higher than the least (0.65/plant) which was obtained from cultivar V003. Cultivars V087 and Benue produced maximum fresh root yield (17.72 to 18.92 t/ha) while cultivars 440293, Benue, TIS 86/0356 and Eruwa-cream produced significant higher fresh shoot yield than all the other cultivars (12.13 to 16.42 t/ha). This study revealed the potentials of different cultivars for diverse use ranging from breeding, weed suppression, to consumption.

INTRODUCTION

Sweet potato, *Ipomoea batatas* (L.) Lam, is an important perennial crop which belongs to the morning glory family or Convolvulaceae (Senanayake *et al*., 2013). It originated from Central and South America and is cultivated worldwide, primarily throughout tropical and sub-tropical Asia and Africa, in hot semi-arid regions where the possibilities of abiotic stresses are acute (Ramamoorthy *et al*., 2022). Lebot (2009), reported that sweet potato is a versatile plant offering various products such as fresh food, processed starch, alcohol and foliage for animal feed. Its storage roots are considered an essential human diet due to their nutritional quality and fibers (of which 40% is soluble fiber, which helps to lower sugar and cholesterol in the blood), which make it the ideal food for people with diabetes, pregnant women and children (Betty, 2011; Allen *et al*., 2012). According to Aladesanwa and Adigun (2008); Islam *et al*., (2014), sweet potato is used as cover crops for weed suppression. Its growth habit which is predominantly prostrates and a rapidly expanding horizontal vine system makes it a good ground cover.

Sweet potato is ranked as the fifth most important food crop in the tropics and seventh in world food production after wheat, rice, maize, potato, barley and cassava (FAO, 2016). It roots and foliage yields more per unit area when compared to other root crops (Sankari *et al*, 2019). Sweet potato fulfills a number of basic roles in global food system, all of which have fundamental implications for meeting food requirements, reducing poverty, and increasing food security (El-Sheika and Ray 2017).

The production, marketing and utilization of sweet potato have expanded in the last decade to almost all ecological zones in Nigeria (NRCRI, 2009). According to FAOSTAT, (2017), Nigeria is the largest producer of sweet potato in Africa and second largest producer in the world with an estimated average production (2010-2014) of 3.67 million tons harvested from 1.38 hectares of land and a total estimated yield of 2.6 tons per hectare.

According to Carpena (2009), several sweet potato cultivars are maintained by various national gene banks all over the world, however, only a few, up to just two in some cases, predominates the sweet potato growing areas in each major sweet potato producing country. The choice of cultivar to grow depends largely on yield (fresh root and shoot yield) and how the produce is utilized.

Therefore, the objective of this study is to evaluate the productivity of 20 sweet potato cultivars under Ibadan conditions and recommend cultivars with better field performance

Materials and Methods

Experimental site

The study was carried out at the experimental field of the Department of Agronomy, University of Ibadan, Nigeria from September to December, 2012. The study areas lies between Latitude 7^{o} 27` N and Longitude $3^{o}$ 45` E and has an elevation of about 210m above sea level. The mean annual rainfall of the area is 1250mm and its pattern of distribution is bimodal. Two seasons prevails in the area, namely wet season and dry season. The wet season extends from April to October while the dry season is between November and March. The land area occupied by the experimental field is 418m^2. Table 1 gives the summary of rainfall and temperature pattern of the experimental site during the period of the field trial.

Table 1: Meteorological conditions of the experimental site during the period of the field trial in Ibadan, Nigeria, 2012

Month	**Rainfall (mm)**	**Min Temp (^{O}C)**	**Max Temp (^{O}C)**
September	224.4	21.9	28.9
October	197.4	22.9	30.2
November	27.5	22.1	33.1
December	0	22.2	31.3
Total	449.3		

Source: International Institute for Tropical Agriculture (IITA) Ibadan weather station, 2012.

Experimental design

The experimental design used was randomized complete block design (RCBD) with four replications. Sweet potato vines of length 25cm per cultivars were planted 30cm apart on the crest of ridges 3m long with a furrow space of 1m left in between two ridges. Each ridge had 10 plants per cultivar per replicate thereby giving a total plant population of 800 plants in all.

Soil sampling and analysis

Soil samples were randomly collected from different parts of the experimental site at depth 0 -30cm with the aid of soil auger. The soils were later bulked together and a representative sample was used for the determination of physical and chemical properties of the soil before trial establishment. The soils of the experimental site are homogenous and have a sandy-loam texture as shown in Table-2.

Table 2: Physical and chemical characteristics of soils at the experimental site prior sweet potato establishment in Ibadan, 2012.

Parameter	Value
Sand (%)	72.0
Slit (%)	14.8
Clay (%)	13.2
Textural class	Sandy-Loam
Chemical Characteristics	
pH (H_2O)	6.60
Organic Carbon (g/kg)	13.6
Available Phosphorus (mg/kg)	19.4
Total Nitrogen(g/kg)	1.90
Exchangeable Bases	(Cmol/Kg)
Ca	1.10
Mg	0.90
K	0.50
Na	0.10
Total Exchangeable Bases	2.60
Exchangeable Acidity	0.50

Observation and data collection

Observation and data were collected at different stages of plant growth and at harvest. Data on length of main vine and number of leaves were collected at 4, 8 and 12 weeks after planting (WAP). Data on percentage ground cover was collected at 5 and 10 WAP. For percentage survival, it was collected at 4 and 8 WAP while root and shoot variables were collected at harvest

Cultural practices

Weeding was done manually at 3 and 7 WAP. The dominant weeds observed during the growth of the sweet potato plants were *Chromolaena odorata*, *Talinium fruticosum*, *Imperata* cylindrical, *Tithonia diversifolia* and *Ageratum conyzoides*. There were no fertilizer, herbicide and pesticide applications. Weevil damage was moderate thereby indicating that most of the sweet potato cultivars are moderately resistant to weevil infestation.

Harvesting

Harvesting was carried out when the plants were exactly 16 weeks old. At the time of the harvest, the shoots have shown sign of senescence and drying which are some of the indicators of maturity in sweet potato plants. Harvesting was done by cutting off the shoots, carefully digging out tubers in other to avoid bruises. The harvesting was carried out manually with the aid of a hoe.

Data analysis

Data obtained from the agronomic characteristics and yield parameters of the 20 sweet potato cultivars evaluated were subjected to analysis of variance (ANOVA) using Genatat Discovery, edition 4, 2011 version. Where means were significantly different, separation was carried out using Duncan's Multiple Range Test (DMRT).

RESULTS

Number of leaves

The number of leaves produced by the 20 sweet potato cultivars evaluated differ significantly ($p < 0.05$). At 4 WAP, cultivar Benue produced the highest number of leaves than all other cultivars except cultivar 199034.1. Cultivar Barth produced significantly lower number of leaves than all others except Arrow Tip and V003 cultivars. At 8 WAP, cultivar Eruwa cream produced significantly higher number of leaves than all cultivars. Cultivar V094 also produced significantly higher number of leaves than all other cultivars and is comparable to the numbers produced by Ex- Oyunga but lower to the numbers produced by cultivar Eruwa-cream mentioned earlier. Cultivars Arrow Tip and Shaba produced significantly lower number of leaves than all other cultivars. At 12 WAP, cultivar Eruwa-cream produced significantly higher number of leaves than all cultivars except that of cultivars Benue, V094, Ex-Oyunga, and V087. Cultivars 440293, 199062.1 and TIS 8164 also produced significantly higher number of leaves but lower when compared to those cultivars earlier mentioned. Cultivars Barth, TIS 8441, Shaba, Arrow Tip and Akoroda produced significantly lower number of leaves than all other cultivars as presented in Figure-1.

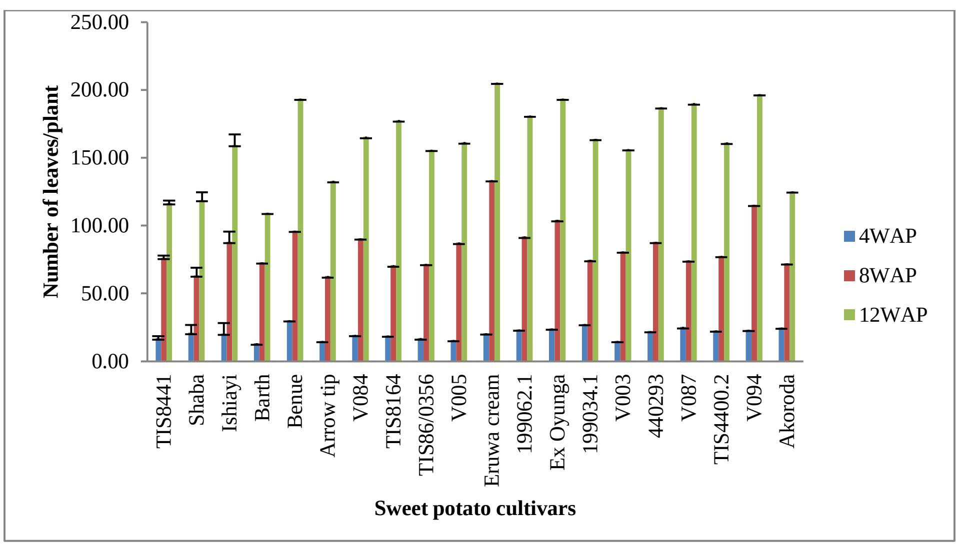

Figure 1: Mean number of leaves of sweet potato cultivars evaluated at the experimental field in Ibadan, Nigeria, 2012.

Length of main vine

The length of main vine among the 20 sweet potato cultivars evaluated differ significantly ($p < 0.05$). At 4WAP, cultivars Shaba and 440293 gave significantly longer length of main vine than all other cultivars except cultivar Benue. Cultivars Ishiayi also gave significantly longer length of main vine than all other cultivars but lower than those earlier mentioned. Cultivars V005, V003 and TIS 86/0356 produced significantly shorter length of main vine than all cultivars except cultivar TIS 8164. At 8 WAP, cultivar 440293 produced significantly longer length of main vine than all other cultivars. Cultivars Shaba, Ishiayi and Benue also gave significantly longer length of main vine but lower when compared to 440293. Cultivars TIS 86/0356 produced significantly shorter length of main vine than all other cultivars. At 12 WAP, cultivars Shaba, Ishiayi and Benue produced significant length of main vine but lower when compared to cultivar 440293. Cultivars TIS 86/0356 produced significantly shorter length of main vine than all other cultivars except cultivars V005 and V003 as presented in Figure-2.

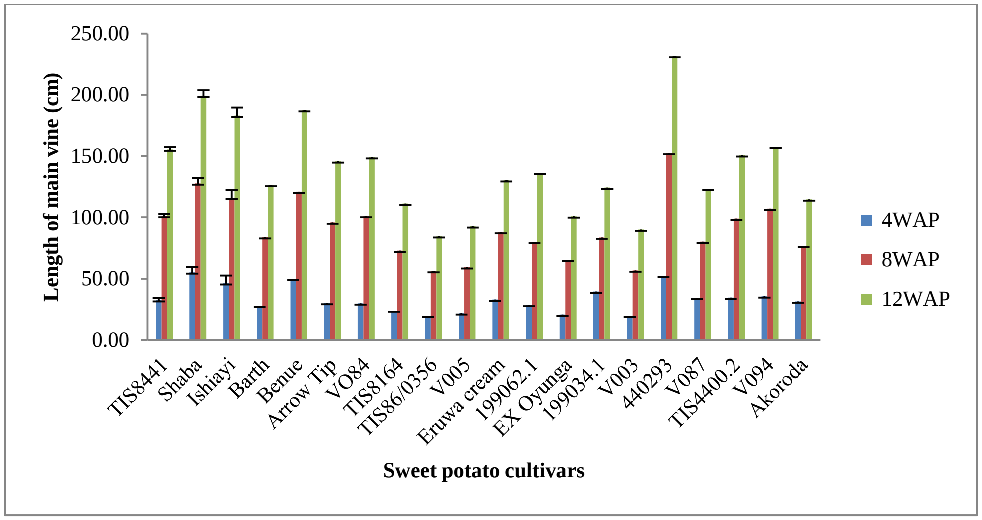

Figure 2: Mean length of main vine (cm) of sweet potato cultivars evaluated at the experimental field in Ibadan, Nigeria, 2012.

Percentage survival and Percentage ground cover

Percentage survival differ significantly ($p < 0.05$) among the sweet potato cultivars evaluated at 4 and 8 WAP. At 4 WAP, cultivars TIS 8441, Shaba, V084, TIS 86/0356, 199034.1, 440293, V087, Barth and Akoroda had significantly higher percentage survival than all other cultivars and comparable to that of Ishiayi, Benue, Arrow Tip and Eruwa- cream. At 8 WAP, cultivars TIS 86/0356, 440293, and V087 had significantly higher percentage survival than all other cultivars but comparable to cultivars Shaba, Barth, Benue, V084, TIS 8164, Akoroda, Eruwa- cream, 199062, V003 and 199034.1

Percentage ground cover also differs significantly at ($p < 0.05$) among the 20 sweet potato cultivars evaluated at 5 and 10 WAP. At 5 WAP, cultivars V084 and 440293 had the widest ground coverage of 44.0% and 42.5%. These were significantly higher than all other cultivars but comparable to that of cultivars TIS 8441, Benue, V087, TIS 8164, Eruwa-cream and Shaba. At 10 WAP, Cultivar V084 gave the widest ground coverage than all other cultivars evaluated. Cultivar 440293 also gave significantly wider coverage than all other cultivars except that of cultivars Benue as presented in Figure-3.

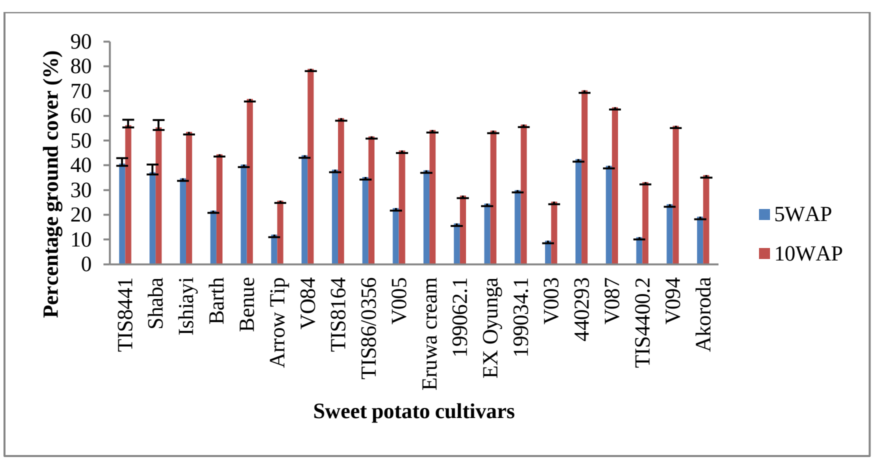

Figure 3: Percentage ground cover of sweet potato cultivars evaluated at the experimental field in Ibadan, Nigeria, 2012.

Tuber and Shoot yield

The fresh tuber and shoot yield produced among the 20 sweet potato cultivars differ significantly ($p < 0.05$) among the 20 sweet potato cultivars. For fresh shoot yield, cultivar 440293 produced significantly higher fresh shoot yield than all other cultivars. Cultivars Benue, TIS 86/0356 and Eruwa-cream also produced significantly higher fresh shoot yield than all other cultivars but lower than 440293 mentioned earlier.

For fresh tuber yield, cultivars TIS 8164, V087 and Benue produced significantly higher fresh tuber yield than all others except that of cultivar 199034.1 but lower than those mentioned earlier. Cultivar 199034.1 also had significantly higher tuber yield than the remaining cultivars except that of cultivar V084. Table -3 shows the mean yield components of the 20 sweet potato cultivars evaluated.

Table 3: Mean yield components of sweet potato cultivars evaluated at the experimental field in Ibadan, Nigeria, 2012.

Varieties	No of tubers/Plant	Fresh tuber weight (t/ha)	Fresh shoot weight (t/ha)
TIS 8441	1.95de	5.05gh	7.17ef
Shaba	2.05cde	5.49fgh	7.61ef
Ishiayi	1.33fg	3.43hij	8.67cde
Bath	1.03gh	2.40ijk	7.92def
Benue	**2.93b**	**17.73a**	**13.29b**
Arrow Tip	0.90gh	4.74gh	9.79c
V084	**2.03cde**	**12.54cd**	**13.50b**
TIS 8164	**2.10cde**	**18.92a**	**7.67ef**
TIS 86/0356	1.98cde	9.04e	13.08b
V005	**0.83gh**	1.56jk	3.94h
Eruwa Cream	**2.50bc**	**15.61b**	**12.13b**
199062.1	1.23fg	6.35fg	**3.83hi**
Ex-Oyunga	1.73ef	**1.17k**	5.34g
199034.1	**3.45a**	**14.17bc**	**9.29cd**
V003	0.65h	1.09k	2.50i
440293	2.48bcd	11.45d	**16.42a**
V087	**2.98ab**	**18.58a**	**6.46fg**
TIS 4400.2	1.15gh	1.48jk	9.69c
V094	1.88e	7.54ef	8.17de
Akoroda	1.15gh	4.47ghi	5.44g
Mean	1.81	8.14	8.60
Std dev.	0.17	0.70	0.47
CV (%)	18.68	17.1	11.02

Means followed by the same alphabets in a column are not significantly different ($p>0.05$)

DISCUSSION

The amount of rainfall received during the experimental period was 449.3mm. This was considered fairly adequate for sweet potato growth and development. According to Onwueme and Charles, (1994), sweet potato does best in region having 750- 1000 mm of rainfall per annum, with about 500mm of this rainfall falling during the growing season. Bergh *et al*., (2012), also reported that sweet potatoes are well adapted to unfavorable environmental conditions and their maturity period ranges between 3-6 months depending on variety.

The soil in the experimental plot was found to have a pH of 6.6 and a sandy loam textural class. This was considered suitable for sweet potato cultivation. According to Onwueme and Charles (1994), soils having a pH range of 5.6 - 6.6 are the most preferred for sweet potato production while Lebot (2009), reported that the preferred soils for sweet potato production are sandy loam soils that are leveled or slightly sloped and well drained.

Ground cover is a field characteristic of sweet potato crop and it is cultivar specific. According to Stanthers *et al*., (2005), sweet potato cultivars with good ground cover are used as cover crop to control weeds or as ground cover to prevent soil erosion. Cultivars V084 and 440293 with percentage ground coverage of 79.0% and 70.3% are good possible inclusion into farming systems where they can serve as cover crop either to control weeds or protect soil from erosion.

Yield is the most important characters which farmers desire in crop production. The physical components of yield in sweet potato are the number and mean the size of storage roots at harvest, which depends on foliage characteristics, the pattern of storage root growth, their mean weight and shape. According to Lebot (2009), all these characteristics vary significantly between cultivars and are under genetic control. The sweet potato cultivars evaluated in this study varies widely for both tuber and fresh shoot yield. This is in agreement with the result obtained by Ulasi *et al*., (2021), who reported between 2.00- 16.02 tons/hectare of fresh storage root yield among 36 sweet potato genotypes during 2015 and 2016 cropping seasons, in Umudike, Nigeria. These yield variations may be as a result of growing conditions, cultivars or season.

CONCLUSION

Among the major root and tuber crops, sweet potato is the only one that has a positive per-capita annual rate of increase in production in Sub-Saharan Africa. Therefore, the selection of cultivars that has high productivity rate becomes imperative. The following conclusions can be made from this study:

1. Cultivars Benue, TIS 8164 and V087 produced highest tuber yield than other cultivars and are considered productive to growers who are more interested in tuber production.
2. Cultivars Eruwa-cream and 199034.1, could be considered more productive for their high fresh tuber and shoot yield
3. Cultivars 4440293 produced high biomass than other cultivars and may be considered productive if shoot yield is more important to the grower.
4. Cultivars V084 and 440290 produced the widest percentage ground cover and are considered as cover crop either for weed suppression or for soil erosion control

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Analysis of Sustainable Small Scale Catfish Farming in South Eastern Nigeria

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ABSTRACT

Small scale Catfish farming involves the rearing of catfish under controlled conditions for socio-economic benefits. It is regarded as excellent aquaculture specie because it grows fast, tolerates extreme temperature, and has a good feed conversion rate. Engaging in small scale catfish production is a way of substantially improving the demand-supply gap currently experienced in the industry. The study examined the socio-economic characteristics of the small scale catfish farmers in the study area, analysed the cost and returns of farmers and examined the influence of socio-economic characteristics on Net-income. Primary data used for the study was collected using well-structured questionnaires which were administered to sampled catfish farmers. In analyzing the data, descriptive statistical tools (frequency counts, means and percentages), enterprise budgeting techniques (Gross margin, Net-farm income) and Multiple Regression Analysis were used to analyse the data. The Return on Investment was ₦1.51 and it implies that the catfish production enterprise generated 1.51 times more income than expenses incurred for the production. In addition, the result indicates a Gross ratio of 66% and a Profitability Index (PI) of 0.34 which means that for every naira earned as revenue, 0.34kobo was returned to the farmer as net income. Out of the nine independent variables included in the model, five; (age, educational attainment, experience, flock size and membership of farmer's society) were statistically significance while the rest were not significance. This result indicated that catfish production is a highly lucrative enterprise to venture into in the study area.

INTRODUCTION

Fish production is very important not only as a source of animal protein to ensure food security but also to improve employment and income towards the elimination of poverty in developing countries (Okezie, et. al., 2008). In view of these positive characteristics, it is perhaps not surprising that fish farming has been among the world's fastest-growing food production sectors for nearly two decades (Tacon, 2001). According to Ugwumba (2003), the demand for fish in Nigeria has been on the increase with demand far exceeding supply. Average fish consumption in Nigeria is 3.5kg person per year which is below the average world consumption estimate of 15kg per person per year (FAO, 2000). According to Nnodim (2014), domestic fish production in Nigeria stands at about 800,000 metric tons while annual demand stands at about 2.7 million metric tons leaving a deficit of 1.9 million metric tons. This is evident in the fact that Nigeria still imports fish into the Country to supplement local fish production.

Catfish, *Heterobrachus bidoscarlis* has been the specie of choice and generally accepted and grown in monoculture or polyculture by fish farmers (Eyo, 2001). According to Ike and Chuks-Okonta (2014), many of the fish farmers in Nigeria focus on catfish production which has a market value of about three times that of tilapia. Catfish being the fastest-growing fish under captivity, It thrives in a wide range of conditions because it is hardy and can tolerate dense stockings and has the potential to create about 30 thousand profitable jobs and generate revenue of US$160 million on yearly basis, which would greatly boost the Nation's economy (Federal Ministry of Agriculture and Rural Development (FMARD, 2016).

ln Nigeria, factors that implicated the decline of capture fisheries include climate change, oil spillage and discharge of industrial wastes which results in pollution of river where people fish from, overfishing and rudimentary technology of fishing. Fish farming had received some attention from the government through her programmes on agriculture such as the establishment of Aquaculture and Inland Fisheries Project and the Presidential Initiative on Aquaculture to arrest this importation problem and to boost fish production however according to Umaru, Okoh, and Ishiwu, 2021 this brought only a minimal success. No doubt, the definite way to lessen the wide gap between the demand and the supply of fish in any country is through increased fish farming..

Based on the above drop, the study seeks to investigate the economics of catfish production with a view to establish its profitability and sustainability. In order to achieve this much-desired goal, catfish farming can provide food, income and a sustainable employment opportunity for the populace. In Nigeria, several studies have been conducted on economics of catfish farming which include economic efficiency and profitability of catfish production in Isoko Area of Delta State, Nigeria (Nkamigbo, et. al., (2014); Profitability analysis of catfish farming in Suleja local government area of Niger State, Nigeria (Yisa,et. al., 2015). However, in southeast, where there is a high rate of unemployment and with an appreciable number of catfish farmers, there is dearth of study on the potential of fish farming, hence this study. The main objective of the study is the economic analyses of catfish farming and its contributions to household poverty alleviation in Nigeria.

The specific objectives are to;

i. Examine the socio economics characteristics of the cat fish farmers.
ii. determine the cost and returns of catfish farming
iii. examine the influence of socio-economic characteristics of the catfish farmers on their net income

METHODOLOGY

The study adopted descriptive survey design. The study is carried out in SouthEast geopolitical zone of Nigeria. The zone comprises five states, namely, Abia, Anambra, Ebonyi, Enugu and Imo. Multistage and random sampling techniques were used to select 405 respondents for the study. At stage I, three States namely, Enugu, Anambra and Imo were randomly selected from the five states in the zone. At Stage II, three Local Government Areas (LGAs) known for catfish production were purposively selected from each of the three States to arrive at nine L.G.As. At stage III, three towns were selected from each of the nine selected L.G.As bringing the total number of towns to 27. The final stage (Stage IV) involved random sampling of 15 catfish farmers from each of the twenty seven selected Towns/Communities, thus arriving at 405 respondents. Primary data for the study and was collected using well structured questionnaire which was administered to sampled catfish farmers in the study areas with the help of trained enumerators and research assistants. Objective one was analyzed using descriptive statistics (means, frequency counts, and percentages). Objective two was achieved using the enterprise budgeting techniques; Gross margin, Net-farm income, Net return on investment, Gross ratio and profitability index. The methods are mathematically given as:

i. **Gross Margin =** Total Revenue – Total Variable Cost

ii. **Net Farm Income =** Total Revenue - Total Cost

Where: Total Cost (₦) = Total Variable Cost + Total Fixed Cost

iii. **Net return investment=** $\frac{\text{Net Farm Income}}{\text{Total Cost}}$

iv. **Gross Ratio=** $\frac{\text{Total cost}}{\text{Total Revenue}}$

v. **Profitability Index (PI)=** $\frac{\text{Net Farm Income}}{\text{Total Revenue}}$

Depreciation on capital items (machines, equipment and buildings) was obtained from the initial costs and useful lives of such fixed items. Straight line method of depreciation was used and the method is given as

$$D = \frac{C-S}{L}$$

Where: D= Annual depreciation (₦), C=Cost of fixed Assets (₦), S=Scrap salvage value (₦), L= Useful lifespan (years)

Objective three was realized using Multiple Regression Analysis. The implicit form of the multiple regression model employed for the analysis is given as:

NET FARM INCOME = f (GENDER, AGE,EDUCATIONAL ATTAINMENT, EXPERIENCE, FLOCK SIZE, MEMBERSHIP OF FARMERS SOCIETY, MARITAL STATUS, EXTENSION CONTACT, FARMING STATUS,HOUSEHOLD SIZE)

Where:

NET FARM INCOME = the amount of Profit attained (₦)

GENDER= this is measured as dummy variables, 1 for male and 2 for female.

AGE= Number of years

EDUCATIONAL ATTAINMENT = Years of formal education.

EXPERIENCE= Years of experience in poultry production.

FLOCK SIZE = Number

MEMBERSHIP OF FARMERS SOCIETY= Number.

MARITAL STATUS = If married = 2, otherwise = 1

EXTENSION CONTACT = Total number of visits/contacts within the period of production

FARMING STATUS = 2 if the farmer is a full time farmer and 1, if otherwise.

HOUSEHOLD SIZE = Actual number

e = Error term

Bo = Constant

$\beta_1 – \beta_{12}$ =Coefficients of the parameter estimates.

The above model was fitted with the data and tried with four (4) functional forms of the multiple regression models; linear, exponential, semi-log and double log. The equation with the best fit was chosen on the basis of conformity with *a priori* expectations of parameters, statistical as well as econometric criteria such as the magnitude of R^2, the t-values of the estimates and, the number of significant variables in each estimated equation.

RESULTS AND DISCUSION

Socio – Economic Characteristics of the Respondents

The Socio- economic characteristics of the respondents as highlighted in Table 1 are Gender, Age, Educational attainment, Number of fish stocked, Marital status, Extension contacts, Farming status, Household Size, experience and membership of Farmer's society. Table 1 shows that 52% of the respondents are males while 48% are females. This may be due to the fact that catfish production in a tedious and time consuming, hence males are made suitable for the job in than females. The table further shows that 46% of the respondents belong to the active age of 31 – 40. This is the economically active and productive age bracket. This is in line with Ugwumba (2011) who stated that age is an important factor influencing production. Production declines as one gets older. Adebayo, *et al.,(*2013) identified that most catfish farmers were in the active age of 31-49 years. The high proportion of age group of less than 51 years shows that they are in their active age; hence, more productivity of fish farming is expected because of the strength and physical ability to manage the fish pond (Williams, *et al.*, 2012). The results further indicated that 9% of the respondents have no formal education, 25% have primary education, 34% have secondary education while 32% have tertiary education. This shows that the bulk of the respondents have secondary and tertiary education. This is important because the level of education of the respondents determines the level of adoption of innovations. This finding supports the results of Adefalu, *et al.*,(2013), Salau, *et al* ., (2014), Olasunkanmi and Yusuf (2014), Okunlola, *et al* ., (2011) and Ideba, *et.al.*, (2013) who found out most catfish farmers are educated to tertiary education. The Number of fish stocked distribution showed that 52% of the farmers have stocked between 101 - 300, 26% have greater than or equals to 100, while 22% have of 301 – 500 catfish. This implies that the areas are dominated by small holder cat fish. Producers. Further analysis showed that 37% of the respondents are married, 50% are single while 13% are widowed, separated or divorced. This implies that cat fish production is mostly the business of married people who usually utilize the labor of the children in running the business. This finding corroborates that Asa, et. al., (2012) who noted that marriage is a highly cherished social value among fish farmers in Akwa Ibom State. The result further shows that 44% of the respondents had no extension contact while 56% had extension contacts. This is important because the level of awareness of innovations is a function of its practicability and production efficiency. This was as a result of the operation of the extension personnel at the grass root in the study area. On the distribution of the respondents according to farming status, the result indicates that 60% of the respondents were full time while 40% are part time. This could be as a result of the business being cited in the rural areas. On the distribution of the respondents according to household size, the result indicated that 35% have a household size of 1 – 3, 41% have a household size of 4 -6 while 24% have a household size of above 7. This implies that cat fish productions do not necessarily require a large household, but a small household that is technically knowledgeable in the business. The distribution of the respondents according to membership of farmer's society (cooperative society) shows that 60% of the respondents belong to farmer's society while 40% do not belong. This is as a result of the fact that most of the small holder cat fish producers live in the rural arrears where cooperatives are more functioning. This disagrees with the findings of Ezike and Adedeji, (2010) who stated that many farmers in the rural area don't enjoy the benefit of cooperative organization including training and credit access to members.

Table 1: Socio –Economic Characteristics Of the Respondents in the Study Area

VARIABLES	FREQUENCY	PERCENTAGES
GENDER:		
Male	212	52
Female	193	48
	405	100
AGE:		
21 – 30	95	23
31 – 40	185	46
41 – 50	87	21
50 and above	38	10
	405	100
EDUCATIONAL ATTAINMNET:		
No Formal education		
Primary education	37	09
Secondary education	101	25
Tertiary education	138	34
	129	32
	405	100
FLOCK SIZE:		
≥ 100	105	26
101 – 300	210	52
301 – 500	90	22
	405	100
MARITAL STATUS		
Married	204	50
Single	149	37
Widowed/Seperated/Divorced	52	13
	405	100
EXTENSION CONTACTS		
No	180	44
Yes	225	56
	405	100
FARMING STATUS		
Full time	245	
Part time	160	
	405	
HOUSE HOLD SIZE		
1 – 3	140	
4 – 6	165	
7 – above	100	
	405	
EXPERIENCE		
1 – 10	95	
11 – 20	106	
21 and above	200	
	405	
MEMBERSHIP OF FARMING:		
Yes		
No	243	60
	162	40
	405	100

Source : Field survey (2022)

Costs and Returns of Catfish Farming in the Study Area

As indicated in Table 2, the cost and returns analysis indicates that a total revenue of N2, 972, 400 was realized by an average catfish farmer for one production cycle. The result also shows that an average catfish farmer invested N1, 969, 933.8 as total costs of production for the enterprise per cycle. These consist of both total variable cost and total fixed cost. The total variable costs (N1, 607, 412. 05) accounted for 81% of the total cost of production and the variable expenses include the cost of stocking, feeding, labour, utility and among other costs. The feeding cost of N1,089, 958 constituted the largest share of the total costs with 55.3% of the total cost. This agrees with the findings of Idisi, et. at., (2019) who reported in their study that the cost of feed carries the highest proportion of the total average cost of production. Cost of feed was followed by cost of stock (Fingerlings, N211,801.51) and labour (N89, 296.28) accounting 10.8% and 4.53% of the total cost of production respectively. According to Yisa, et.al., (2015) fingerlings, labour, feed and water are essential inputs in catfish farming. The fixed cost covers rent and pond construction, tax and implements like; net, scale, pumping machine, shovel among others. The Gross margin of the enterprise for one production cycle was ₦1, 364, 987.95 while the Net farm income realized was 1,002, 466. 20. The Return on Investment was ₦1.51 and it implies that the catfish production enterprise generated 1.51 times more income than expenses incurred for the production. On the other hand, it indicates that every N1.00 invested, catfish production yielded a cash flow N 1.51. This suggests that the enterprise is in a healthy financial state. The Net return on investment shows that, for every naira invested in the production of catfish about N 0.51 returned to the farmer as income. In addition, the result indicates a Gross ratio of 66%. The implication of this is that 66% of the total revenue generated from the sales of the outputs was used to pay off all the costs incurred in the production. Profitability Index (PI) was 0.34 which means that for every naira earned as revenue, 0.34kobo was returned to the farmer as net income. This result surely indicates that cat fish production is highly lucrative enterprise to venture into in the study area.

Table 2: Costs and Returns of Catfish Farming in the Study Area

ITEMS	AMOUNT (₦)	
REVENUE:		
Sales: Average quantity of table size Catfish sold in kg 2477@N1200 per kg	2,972,400	
TOTAL REVENUE:	2,972,400	
ITEMS	AMOUNT (₦)	% OF TOTAL COST
VARIABLE COSTS		
Fingerlings	211,801.51	10.75
Fish feed/Supplement (5-6months)	1,089,958	55.32
Lime/Fertilizer	43,473.18	2.206
Labour	89,296.28	4.53
Fuel [for pumping water]	70,300.00	3.56
Transportation	47,351.08	2.40
Utilities/Miscellaneous	55,232.00	2.80
TOTAL VARIABLE COST	1,607,412.05	
FIXED COST		
Depreciation on		
Building	254,153.59	12.70
Deep well	11,500.00	0.583
Concrete tanks	15,554.11	0.789
Plumbing materials]	3,010.45	0.15
Ponds [Earthen pond/vats/plastic	49,806.00	2.52
Generator	15,261.00	0.774
Water pump	8,378.60	0.425
Wheel barrow	1,560	0.079
Shovel/Bowls/Cutlass	2,175	0.110
Pond net cover	1,123	0.057
TOTAL FIXED COST	362,521.7	
TOTAL COST	1,969,933.8	
GROSS MARGIN	1,364,987.95	
NET FARM INCOME	1.002, 466.2	
RETURN ON INVESTMENT	1.51	
NET RETURN ON INVESTMENT	0.51	
GROSS RATIO	0.66	
PROFITABILITY INDEX	34	

Influence of the Socio – Economic Factors on the Farmers on Net Farm Income

The multiple regression analysis was used to examine the influence of socio – economic factors (independent variables) of the respondents including age, gender, educational at attainment , Experience, Number of fish stocked, membership of Farmers Society , Marital Status, Extension Contacts, Farmers Status and Household Size on Net Farm Income (NFI) (the dependent variables). The MINITAB statistical package was used to run the analysis. Out of the four functional form of the regression (Table 3), output of semi – log form was best in terms of values of the coefficient; F-Statistics, $R^{2,}$ adjusted R^2 and Durbin – Watson statistics, and appropriateness signs of the regression coefficients and was therefore chosen as the lead equation.

The F – statistic value of 204.41 was significant at 5% possibility level. This is an indication of the overall significance and goodness of fit of the model. The R^2 value of 79% showed that 79% of variation in the net farm income of the respondents was due to the variation in the independent variables whiles the remaining 21% was attributed to error. Further result of the regression analysis showed that out of the nine independent variables included in the model, five; (age, educational attainment, experience, Number of fish stocked and membership of farmer's society) were statistically significance while the rest were not significant. The coefficient of age had positive and significant influence on net farm income at 5% probability level. This implies that the older farmers utilized their experience and accumulated capital to achieve better productivity and earned higher net farm income than the younger ones. This agrees with Ugwumba (2011) that the older farmers on catfish production are likely to make higher net farm income because of experience and accumulation of capital than younger farmers. The coefficient of educational attainment had a positive relationship with net farm income. This implies that education is a driving force for profit making. The coefficient of educational attainment had a positive relationship with net farm income. This implies that education is a driving force for profit making. This support the argument of the theory of Solo (1959) as cited by Kasum (2019) that knowledge is a key to efficient resource management and ease of adoption of new technology by farmers. This result is contrary to the work of Ugwumba and Chukwuji (2010) on the economics of catfish production in Anambra State, Nigeria. They noted that the level of education does not determine the amount of profit realised in fish production. The coefficient of years of farmers experience in catfish farming was positively related to farmer's net income. This proves that years of experience in catfish farming improves efficient use of input resources by the farmers. Economic scholars argued that efficiency increases with an increase in production experience (Ike and Ugwumba 2011): A positive co – efficient of stock size is according to a prior expectation. The positive relationship implies that an increase in stock size will result to an increase in output level and consequently net income. This is contrary to the work of Ele, *et. al.,* (2013) on economic analysis of fish farming in Calabar, Cross River State, Nigeria. They reported that one does not need to have much experience before going into fish production. The coefficient of membership of farmer's society is positively related to farmer's net worth. This implies that farmers who belong to cooperative societies can easily access loan from financial institutions which will enhance proper stocking and eventually high farm income.

Table 3: Influence of the Socio–Economic Factors of the Farmers on their Net Farm Income

	Linear	Experiential	Semi - log	Double log
Constant	392.32	2.973	7.33	10.19
Age	36.33	-0.007	-3.76	-0.02
	(3.56)**	(-3.067)**	(-2.36)**	(-3.41)**
Educational attainment	14.96	0.006	2.28	0.08
	(3.18)**	(2.74)**	(3.11)**	(2.95)**
Experience	10.34	0.004	2.86	0.06
	(2.13)**	(2.32)**	(3.46)**	(1.78)**
Number of fish stocked	-79.84	-0.007	-3.76	0.04
	(-6.34)**	(-3.067)**	(2.36)**	(1.08)
Membership of farmers society	-44.3	0.09	2.62	-6.35
	(-1.23)	(0.97)	(-1.84)**	(0.030)
Marital status	17.43	0.003	0.37	0.06
	(0.73)	(1.813)	(0.66)	(1.28)
Extention contact	3.46	0.003	1.76	0.03
	(0.81)	(1.462)	(1.34)	(1.26)
Farmers status	14.30	*0.005*	0.01	-0.07
	(0.18)	*(-1.33)*	(-2.33)	(1.65)**
Household size	10.34	0.003	2.77	-0.06
	(2.3)**	(0.412)	(1.39)	(-1.38)
R^2	71%	69%	79%	68%
R^2 (Adj)	68%	65%	77%	63%
F. Statistic	20.36	12.42	204.41	14.76

CONCLUSION AND RECOMMENDATION

The study reveals that catfish production is viable venture and consequently if the production processes are technically and resourcefully managed, it is capable of not only yielding a reasonable net return over time to any catfish farmer, but, it will go a long way to help in reducing Green- House-Emissions. It can also be adduced from the study that catfish production will timely and in future help in maintaining natural conservation and climate changes. Based on this study the following recommendations are made: Since catfish production are profitable and of immense help in maintaining environmental friendliness, attention should be paid to the catfish farmers to ensure that the best practices are adopted for sustainability and agric-business. There is need for promotion of raw infrastructure, better credit facilities and proper awareness to climatic changes by the government at all levels.

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Effect of Selected Organic Soil Amendments on Soil Physico-Chemical Properties, Growth and Yield Of yellow Pepper (*Capsicum annum*)

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K E Y W O R D S

Soil chemical properties,
Soil organic amendment,
Soil physical properties,
Yellow Pepper

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A B S T R A C T

A field experiment to investigate the effects of different forms of organic manure on physico-chemical properties of clayey loam ultisol, growth and yield performance of yellow pepper plants, Capsicum annum (L.) var. was carried out at the Research Farm of the Agricultural and Bioresources Engineering, Faculty of Engineering, Nnamdi Azikiwe University Awka, Anambra State, Nigeria. The experiment was laid out in a Randomized Completely Block Design (RCBD) with three (3) replications. Treatments used were 10t/ha cassava peel biochar (CPBC), 10t/ha poultry manure (PM), 10t/ha cow dung (CD) and 5t/ha+5t/ha of their various combinations with one control. Morphological data were collected at two weeks interval after transplanting. Data collected were subjected to ANOVA. Significant mean differences were separated using LSD(0.05). At 12WAP, plants that received a combination of PM and CP had significantly higher heights, while the widest leaf area (116.6cm^2) was obtained from those that had CD.Highest fruit weight per plant was recorded with cow dung (0.63kg), while cow dung + poultry had the highest number of fruit (170.3). The pH of the amended plot ranged from 4.73-4.99. The exchangeable bases (Ca^{2+} and Mg^{2+}) were significantly higher in the plot amended with cassava peel biochar with values of 1.76cmol/kg and 1.44cmol/kg, compared to other amendments. There was also, significantly higher Organic Carbon values in the plots amended with Poultry manure. Based on the results, it could be deduced that the plot amended with cow dung + poultry manure significantly improved the soil fertility. Therefore, should be recommended for yellow pepper production in the study area.

INTRODUCTION

Food crisis is a global challenge and a great threat to the existence of human race. According to Akinrinde (2006), the soil is a very crucial factor in food production, and unproductive and infertility on soil can result in food insecurity. Nigeria soils have a high potential for crop production, but the yield levels obtained are usually low due to poor soil management. It is pertinent to improve soil quality and consequently, crop production without damage to the environment in areas with low crop production due to low soil quality. This problem could be solved through the use of soil organic or inorganic amendments Eleduma *et al*., (2016).

Davis and Wilson (2005), defined soil amendment as any material added to a soil to improve its physico-chemical properties. These materials include biocharwith high surface area and porosity which has major impact on soil physical properties by its feedstock. Many studies have found that soils treated with Biochar has the potential characteristic of increasing water retention and nutrient capacity especially in depleted tropical soils (Bakewell-Stone, 2011). In addition to this, Poultry manure (PM) contains nutrient elements that can support crop production and enhance the physico-chemical properties of the soil (Omisore *et al.,* 2009). Like other soil organic amendments, cassava peels are potential source of organic matter and plant nutrients. Its management includes direct incorporation into the soil, burning or processing them into a more stable organic amendment called Biochar. Similarly, cow dung is an important source of organic matter. It increases the soil buffering capacity, thus help regulating soil acidity, increase water holding capacity and infiltration rate.

Yellow Pepper (*Capsicum annuum L.*) is an important agricultural crop that belongs to Solanaceae family. It is a spice crop in high demand which commands a high price in the South Eastern parts of Nigeria because of its bright yellow colour, aroma, nutritional and medicinal value which distinguishes it from other pepper varieties.

The aim of this study was to evaluate the effects of cassava peels biochar, poultry manure cow dung and their combinations on growth and yield of yellow pepper.

Specific objectives:

i. To determine the effect of the soil selected organic amendments on the physical and chemical properties of the soil.

ii. To determine the effect of the combination of two of the applied treatments on the growth and yield of yellow pepper.

MATERIAL AND METHODS

The study was conducted at the Teaching and Research Farm of the Department of Soil Science and Land Resources Management, Faculty of Agriculture, Nnamdi Azikiwe University, Awka. Awka is located in the South-Eastern part of Nigeria. It lies within Latitude 62488^{o}N and Longitude 7.18289^{o}E. The area is characterized by a mean annual rainfall of 1828mm, maximum and minimum temperature of 32^{o}C and 24^{o}C respectively, and a relative humidity of 75-85% on the average of the dry season and raining season with general lower evapotranspiration. The soil is well drained and mostly sandy-loam to loamy in plains and Hydromorphic along the flood plains. The soils in the area are rich in mineral content and therefore support the high agricultural productivity in the area.

10t/ha Poultry Manure (PM), 10t/ha Cow Dung (CD), 10t/ha Cassava peel biochar (CP),5t/ha+5t/ha Poultry Manure and Cow Dung, 5t/ha+5t/ha Poultry Manure and Cassava Peel (PM+CP), 5t/ha+5t/ha Cow Dung and Cassava Peel Biochar (CD+CP), (5t/ha+5t/ha) Cow Dung and Poultry Manure (CD+PM) and Control (C) (zero treatment) were applied on the experimental plots by incorporating them into the soil and left for 7days to equilibrate/cure before planting. The experiment was laid out in a Randomized Complete Block Design (RCBD) with seven treatments and three replications.

The seedlings were transplanted 6weeks after planting to their allocated plots at a spacing of 45cm×75cm. Organic manures were incorporated into the beds at three weeks prior to planting. Weeding was done manually at every two weeks interval using hoe and hand.

Data Collection and Statistics

Prior to the commencement and at the end of the experiment, soil samples were collected randomly at a depth of 0-15cm with the aid of soil auger from the experimental plots after which they were mixed together to form a composite sample. They were later air dried, crushed and passed through a 2mm mesh sieve and taken to laboratory to determine the routine soil chemical properties using standard procedures.

Particle size distribution was determined using the Bouycous Hydrometer Method of Gee and Or (2002). pH was determined in glass electrode using 1:2.5 soils:water ratio (IITA, 1989). Total Exchangeable acidity (Al^{3+} and H^+) was determined by titration method using 1N KCl (IITA,1989). Exchangeable (Ca^{2+} and Mg^{2+}) were determined in 0.25N ammonium acetate (NH_4OAC) at pH 7. EDTA titration method was used to determine Ca $^{2+}$and Mg^{2+} (Thomas, 1982). Exchangeable K^+ and Na^+ were extracted using 1N neutral ammonium acetate (NH_40AC) and determined photo-metrically using flame photometer (Thomas, 1982). Soil organic carbon content was quantified by Walkey-Black wet oxidation method as described by Nelson and Sommers (1982).Total Nitrogen was determined by kjehdahl digestion method using concentrated H_2SO_4 and a Sodium copper sulphate catalyst mixture (Bremner, 1996). Plant morphological data collected were plant height (cm) using measuring tape to measure the height of four (4) plants per plot from the soil surface to the tip of the plant where the youngest leaf branches and the average value was recorded, number of leaf per plant obtained by visual observation. All the data were collected at two weeks interval after transplanting (WAT) and Number of fruit and its weight in kg at 10 to 12 weeks growth stage.

The data collected were subjected to Analysis of variance (ANOVA) and means were separated using Fishers Least Significant Different (F-LSD) at $P<0.05$.

RESULTS AND DISCUSSION

Physico-chemical properties of soil before planting

The physico-chemical properties of the soil before planting were presented in table 1. The results showed that the soil texture was sandy loam with pH of 5.23 which shows moderate acidity and contain moderate organic carbon, total nitrogen and high in exchangeable acidity. The soil also contained high phosphorus indicating high fertility status.

The organic amendments used shows moderate acidity with pH of 5.3, 5.5 and 5.8 (table 1) respectively. It also shows good amount of chemical nutrients as measured which is an indication that the pepper thrives when the organic amendments was applied.

Table 1: Physico-chemial properties of soil before planting and the chemical properties of cassava peel, cow dung, poultry manure used.

SOIL PROPERTIES		Nutrient content		
	VALUE	Cassava Peel Biochar	Cow Dung	Poultry Manure
Textural class	SL	-	-	-
%Sand	54.40	-	-	-
%Silt	27.00	-	-	-
%Clay	18.60	-	-	-
pH in H_2O	5.23	5.3	5.5	5.8
TN(%)	0.11	0.89	1.08	1.58
Av.P(mg/kg)	11.20	17.8	13.9	18.8
OC(%)	1.32	10.37	12.45	18.35
Ca^{2+}(cmol/kg)	3.20	1.93	1.48	6.00
Mg^{2+}(cmol/kg)	1.00	1.58	1.90	1.50
K^+(cmol/kg)	0.27	0.02	0.07	0.03
Na^+(cmol/kg)	0.20	0.02	0.03	0.02
Al^{3+}(cmol/kg)	0.44	-	-	-
H^+(cmol/kg)	2.6	-	-	-

SL = Sandy Loam

Effect of cassava selected soil organic amendments and their combinations on selected chemical properties of the soil

Effects of the treatments on the soil chemical properties (0-15cm) were shown in table 2. Apart from the Exchangeable Base Cations which differed significantly. The treatments effects on the soil total N, organic carbon, pH, available phosphorus and exchangeable acid cations did not differ significantly. However, these parameters were consistently higher in the plot that received any of the organic manure relative to control. This may imply that the treatment resulted to priming action (when organic materials were applied). This is in agreement with Eleduma *et al*., (2016), who reported that the application of different rates of cow dung at different rates slightly increased the soil pH value, percentage T.N, OC, Ca and Mg.

Table 2: Effect of selected organic soil amendments and their combinations on selected chemical properties of the soil .

SAMPLE	pH (H_2O)	% OC	% T.N	Ca^{2+}	Mg^{2+}	K^+	Na^+	Al^{3+}	H^+	P
				(Cmolkg^{-1})				(mgkg^{-1})		
CP	4.730	0.42	0.333	1.764	1.436	0.035	0.347	0.093	1.387	0.327
CD	4.96	0.37	0.333	1.759	1.349	0.039	0.344	o.480	1.4 33	0.454
CD+CP	4.90	0.35	0.030	1.623	1.391	0.037	0.332	0.360	1.633	0.226
CD+PM	4.81	0.34	0.026	1.483	1.458	0.039	0.409	0.213	1.933	0.354
PM	4.99	0.82	0.066	1.698	1.474	0.049	0.345	0.347	1.787	0.357
PM+CP	4.96	0.57	0.049	1.298	1.278	0.001	0.341	0.449	2.268	0.357
Control	4.76	0.43	0.035	1.398	1.316	0.019	0.332	0.480	1.613	0.349
$LSD_{0.05}$	Ns	Ns	Ns	0.06	0.102	0.006	0.011	Ns	Ns	Ns

Effect of cassava peel biochar, cow dung, poultry manure and their combination on plant height and number of leaves

The response of yellow pepper to the selected treatments on the vegetative growth (plant height and number of leaves is presented in table 3. The response shows that significant effect ($p<0.5$) was observed with the treatment means at 8 WAP compared to other treatments.At 12 WAP, the highest plant height was recorded on the plots that received PM+CP, though, this was not statistically different from other treatments as there mean values differed.

Also, the effects of treatment on the number of leaves were recorded (table 3) and it was observed that there was significant difference among the treatment meansat 4WAP unlike other growth stages measured which did not show any statistical significance among the means, though there difference was clearly stated, but statistically, they were not significant. The highest number of leave (61.6) was produced from application of PM + CP at 12 WAP, while the least value (31.2) was recorded on the plot that received CD+CP. This is in agreement with Eleduma *et al*., (2016), who reported that nutrient availability determines plant vegetative growth. The consistent poor performance of control plots and those with low level of nutrient showed that plants tents to thrive at their optimum level when nutrients are available in adequate amount.

Table 3: Effect of cassava peel biochar, cow dung, poutry manure and their combination on plant height.

	Plant Height (cm)					No. of Leaves				
SAMPLE	4WAP	6WAP	8WAP	10WAP	12WAP	4WAP	6WAP	8WAP	10WAP	12WAP
CP	15.42	20.3	21.8	39.8	36.2	6.92	11.7	24.1	39.6	46.4
CD	25.83	25.6	34.1	41.8	40.5	10.58	14.4	37.7	42.3	49.7
CD+PM	21.79	23.6	25.2	34.3	41.0	12.33	22.2	37.5	97.4	36.8
CD+CP	20.89	17.2	22.0	30.4	32.2	6.83	13.2	26.6	26.4	31.2
PM	21.75	18.6	28.2	44.4	37.7	8.25	20.2	32.0	86.0	58.3
PM+CP	24.67	21.5	27.1	41.3	48.0	10.42	18.7	37.3	76.0	61.6
Control	19.44	26.6	20.3	32.9	30.2	5.50	12.5	29.5	36.0	43.4
LSD0.05	NS	NS	8.23	NS	NS	2.963	NS	NS	NS	NS

Effect of the selected organic amendments and their combination on fruit weight and number of fruit.

The response of the crop to application of the selected soil amendments on fruit weight per plant was shown in table 4. Relatively, it could be observed that plots treated with CP biochar and CD have the highest fruit weight than other plots that received other treatments. The values obtained from all the treatment were significantly different from each other.

Similarly, it was shown that highest number of fruit (170.3) was recorded on the plots treated with the combination of CD+PM, while the lowest value (40.0) was recorded against the plots treated with the combination of CD+CP.

Table 4: Effect of selected organic amendments and their combination on fruit weight and Number of fruit.

Type of organic amendments	Weight Of fruit (kg)	Number of fruit
CP	0.60	88.7
CD	0.63	63.3
CD+PM	0.16	170.3
CD+CP	0.52	40.0
PM	0.31	72.0
PM+CP	0.25	129.3
Control	0.57	57.3
LSD0.05	0.09	7.76

CONCLUSION

Cassava peel biochar and poultry treatments gave high Ca^{2+} and Mg^{2+} whereas Al^{3+} and H^+ were relatively low. The exchangeable bases and acidity were at good level thereby improving and sustaining the soil fertility, while the percentage OC and N where low in all the plant. Based on growth parameter of the test crop it was seen that poultry manure + cassava peel biochar had highest height at 12WAP and cow dung + poultry had the highest number of leave. In terms of fruit yield, cow dung + poultry produce the highest fruit yield while cow dung +cassava peel biochar had the least number of fruits. From all indication, cow dung + poultry manure could be considered more suitable for yellow pepper production in the studied soil.

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Early and Late-Season Maize Landraces Performance on Selected Weed Control Practices

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K E Y W O R D S

Early Maize production,
Late-Season Maize production,
Weed control method.

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A B S T R A C T

This experiment was conducted in 2021 and 2022 cropping season at the Teaching and Research Farm of Department of Crop Science and Horticulture, Chukwuemeka Odumegwu Ojukwu University, Igbariam, Anambra State, to assess the performance of selected weed control methods under rain fed maize production in three different successive months. This study was laid out as a 3x4 factorial experiment in randomized complete block design (RCBD) with three replications. The selected cultivars was the main factors (Oka Bende, Oka Abakaliki and Oka Nsukka) while the four weed control method (Check [No weeding], Hoe weeding, Pre-emergence and post emergence) consisted of the sub-factor. The selected maize landraces responded positively to the weed control methods especially 'Oka Nsukka' and 'Oka Bende' in both seasons and adapted easily in Igbariam. Oka Nsukka, in the early season, gave the best grain weight per 100 seeds followed by Oka Bende while Oka Abakaliki had the best grain yield in the late season planting. The results obtained indicated that, a combination of pre-emergence herbicide and hoe weeding at 6WAS ensured that the weeds are adequately controlled and yield maximized.

INTRODUCTION

Maize (*Zea mays*) is regarded as one of the most important cereal in the world after wheat and rice with regard to cultivation area and level of production. In Africa, maize is also the second important food crop after rice (FAOSTAT, 2014). It is capable of producing well under appropriate season in most parts of the world where farming it is cultivated (Akande and Lamidi, 2006). It is used as human food, ruminant and poultry feed and industrial products (Bibi *et al*., 2010). It contributes about 6.4% to the total grain production in Nigeria and occupies an important position in the national economy; as it is a good source of food for people, feed for poultry and folder for livestock. About 7.0 million metric tons was produced in 2003 from 3.2 hectares and has risen to 11.6 million tons (MMT) in 2021/2022 (USDA, 2022). Maize cultivation in Nigeria also done in combination with other crops (mixed cropping) to give it comfortable advantages over most other food crops. The consumption pattern of maize varies in Nigeria among the states, but maize is generally consumed as green maize, breakfast cereals, baby food, and the different types of preparation for local dishes (FAOSTAT, 2011).

However, out of the three major developing region of the world, Africa is the only one in which the index of per capital food production has decrease steadily during the last two decades. As a result this circumstance, the spectra of hunger and malnutrition is perpetually hanging over the countries of the continent where an estimated 35 percent of the population, some 140 million people, largely children and women suffer from hunger and malnutrition (CSA, 2010). Furthermore, the full potential of this very important crop is yet to be attained; especially among the local farmers due to a number of factors ranging from insect pests, climate change, and more especially an effective and efficient weed control methods.

Weed control is major contributor to the labour input for the production of maize crop in Africa. Weeds are one of the major problems in crops and maize production around the world. Weeds compete with crops for nutrients, water, light and space (Bogatek *et al*., 2006). Weeds also differ in their competitive abilities which vary according to conditions and the time of year. Weed management is, therefore, a major concern in any agricultural system. The competition between weeds and maize at critical growth stages has the capacity to reduce both the quality and quantity of maize yield by over 30% (Mahmood and Ali, 2009, Ahmed *et al.,* 2014). For controlling weeds in crop fields, farmers are generally adopting mechanical, cultural, biological and chemical control methods. According to Ahmed *et al.* (2015), using physical weed control methods as tedious, time consuming and exhaustive, thus, farmers tends to move toward other alternative methods due to labour crisis during critical period of weed control in crops. While, the mechanical methods are still useful but are unable to effectively control weeds successfully due to the absence of right machinery especially on small and medium scale level (Chikoye *et al.,* 2007). According to Ahmed *et al.* (2008), the judicious and right use of a different combination of herbicides as pre-plant, pre-emergence and post-emergence can provide effective and efficient weed control. Chikoye *et al.* (2005) earlier reported that chemical weed control may be cost-effective, faster and better weed control method. Managing weed populations through modification of the cropping pattern has been reported to be component of integrated weed management (IWM) in maize a number of cultural practices including alteration in population density (Nurse and Di Tommaso, 2005) and planting dates (William, 2006), row spacing, maize leaf orientation (Norsworthy and Oliveira, 2004), etc. have been studied with the aim of improving the crop's ability to establish dominance over weeds, thereby enduring competitive stress caused by the weeds. However, in the last decade, crop modeling has been used to determine optimal planting dates for maize in the temperate regions (Anapalli *et al.,* 2006). Only very few of such studies have been conducted in tropical African countries, despite the fact that maize is one of the most important cereal crops in the continent. Keeping these challenges in view, this experiment seeks to know the response of maize landraces/cultivars common in the South Eastern Nigeria to various weed management practices and to assess the most efficient of different weed management control methods in the growth and yield parameters of maize production in both early and late-season plantings.

MATERIALS AND METHODS

Experimental Site: The field experiment was carried out during 2022 cropping season. at Chukwuemeka Odumegwu Ojukwu University, Igbariam Campus, Anambra State. It is located in the tropical rain forest zone of South-eastern Nigeria at latitude 6^0 26' N and longitude 6^0 94' E. The soil of the area is characterized by deep porous soil derived from sandy deposits in the coastal plains which are highly weathered, low in mineral reserve and natural fertility. The area is also characterized by minimum and maximum temperatures of between 30^0C and 45^0C respectively.

Experimental Design: The experiment was 3x4 factorial combination laid out in a randomized complete block design (RCBD) and was replicated three (3) times. Three cultivars was main factor while four (4) weed management practice was sub-factor constituted (12) treatment combinations with an inter row spacing distance of 0.75m and intra row spacing of 0.25m with 3m long ridges. Total experimental plots were 36 plots.

Land preparation: The experimental site measuring 14m×14m was marked out. The field was manually cleared and packed using cutlass, spade, rake and tilled very well and prepared into fine tilt. The planting was done on ridges.

Sowing: Maize was planted on 22nd April, 2022 representing the early season planting while the late season planting was done 26th August, 2022, at an inter row spacing of 0.75m and intra row spacing of 0.25m within the row of 3m long. Two seeds were sown per hole at 5cm depth.

Weeding: Four different weeding strategies was applied. Check (No weeding) (W0), physical method with hoe weeding (twice) at 3 and 6 weeks after sowing (WAS) (W1), chemical method with pre-emergence herbicide (Atrazine 3ml/L of water per plot) was applied immediately after sowing followed by hoe weeding at 6 WAS (W2) and post emergence herbicide (Nicosulphuron 3ml/L per plot) using a knapsack sprayer at 3weeks after sowing (W3) to manage weeds on experimental field.

Fertilizer Application: The application of N:P:K (15:15:15) fertilizer at the rate of 100 kg/ha was done to ensure an effective utilization at 4 and 7 weeks after sowing (WAS) (Balasubramanian *et al*., 2008).

Source of Sowing Materials: The seed of three (3) different maize cultivar used were sourced from ADP, Ministry of Agriculture Anambra, Abia and Ebonyi State in South- Eastern Nigeria. The seeds viability was also tested.

Date Collection: Data was collected on the following:

Plant height: this was done at tasseling. Three maize plants were randomly selected from each plot as a representative sample. The measurement was taken from the base of the plant to the last leaf with the help of measuring tape (cm).

Stem girth: this is achieved by measuring the girth with thread, which is placed on calibrated rule in cm for the actual value.

Leaf area: This was determined by measuring the length and breadth of the leaf with measuring tape and then multiplied it with a constant (0.75) as recommended by Musa and Usman (2016). The leaf length was measured from the base of the leaf to the tip while the breath of the leaf was measured across the base.

Number of Cobs: this is the number of maize cobs per plant. This was obtained by counting the number of cobs on each plant stand.

Cobs fresh weight: this is the total fresh weight of harvested cob per plot measured in (kg). This was obtained by harvesting the entire fresh cob in each plot and weight it using weighing balance.

Cobs at dry weight: this is the total dry weight of the harvested cob per plot after sun drying it in (kg).

Grain weight/100 seeds (%): is determined by counting out hundred pieces of the maize grains from the cob of each plot and weight it on digital weighing balance in (g).

Weed density and weed biomass: Data on weed density and biomass was collected from several laying of 50cm x 50cm quadrat ten times across a diagonally transect on the experimental plot. Weed sample was collected and counted separated according to their species (Akobundu *et al*., 2016).

Statistical Analysis: All data collected was subjected to analysis of variance (ANOVA) using Gen-stat release 10.3 statistical software. The means was separated using Fisher's Least significant difference (F-LSD) at 5% probability level.

RESULTS

Soil properties of the experimental site

In order to ascertain the physical and chemical properties of the soil at the experimental site, the soil analysis was carried (Table 1). The result obtained showed that the soil textural class was sandy clay loam. The soil pH was 5.98. The values for nitrogen, phosphorus and potassium which the elements mostly leached are 0.055 (%), 3.89 ($mgkg^{-1}$), and 0.26 ($cmolkg^{-1}$) respectively.

Weed flora composition

Pre-weed sampling was also done to know the weed flora composition of the study site (Table 2). The sampling showed that a total of ten (10) weed species belonging to eight (8) families existed in that location. The result indicated that *Sida acuta* followed by *Cynodon dactylon* and *Calapogonium mucunoides* dominated the experimental sites.

Effect of maize landraces and weed control methods on maize growth parameters at 4 and 8 weeks after sowing (WAS) in the early and late-season planting

Table 1: Physical and chemical properties of soil at the experimental site taken at 0–15cm depth

Parameters	Value
Clay	230 (g/kg)
Silt	210 (g/kg)
Fine sand	420 (g/kg)
Coarse sand	160 (g/kg)
Textural class	Sandy clay loam
Bulk Density	1.39gm-3
Total porosity	48.92 (%)
Moisture Content	20.52 (%)
Dispersion Ratio	0.87 (%)
Aggregate Stability	17.02 (%)
Hydraulic conductivity	4.59 (cmhr-1)
pH (H2O 1:1)	5.98
Oxygen Content	0.76 (%)
Nitrogen	0.055 (%)
Available Phosphorus	3.89 (mgkg-1)
Calcium (Ca2+)	1.5 (cmolkg-1)
Magnesium (Mg2+)	1.3 (cmolkg-1)
Sodium (Na+)	0.24 (cmolkg-1)
Potassium (K+)	0.26 (cmolkg-1)
Exchangeable Cation Exchange Capacity (ECEC)	4.99 (cmolkg-1)
Base Saturation	87 (%)

Source: Agricultural Development Programme (ADP) Soil Laboratory Unit.

Table 2: Pre-weed species density and frequency percentage at the experimental site.

S/No.	Species	Family	Total	%/Frequency
1	*Digiteria abyssinica*	Poaceae	11	9.65
2	*Cynodon dactyion*	Poaceae	13	11.40
3	*Calandem bicolor*	Araceae	7	6.14
4	*Phyllaninus urinaria*	Phyllanthaceae	12	10.53
5	*Chromolaena odorata*	Asteraceae	11	9.65
6	*Calapogonium mucunoides*	Fabaceae	13	11.40
7	*Sida acuta*	Malvaceae	15	13.16
8	Asystasia gangetica	Acantheceae	11	9.65
9	*Alternathera brasilliana*	Amaranthecae	9	7.89
10	*Axonopus compressus*	Poaceae	12	10.53
		Total	114	100

Plant height: The height of maize did not significantly differ among the cultivars in both early and late-season cropping period, but weed control methods had significant effect on maize height in both seasons at 4 and 8WAS (Table 3). The interaction between maize variety and weed control methods had not significant effect on maize height in both seasons as well at 4 and 8WAS. In the early-season at 8WAS, Oka Bende (195.30cm) was taller than the rest while Oka Abakaliki (202.00cm) in the late-season at 8WAS produced the tallest plants.

Under the weed control methods used, maize varieties in plots treated with pre-emergence herbicide (+ hoe weeding at 6WAS) gave the tallest plants in the early-season at 4 and 8WAS. Similar trend was also observed in the late-season.

Stem girth: Maize varieties stem girth differed significantly at 4WAS in both seasons whereas, at 8WAS it did not (Table 3). The result also indicated that the weed control methods significantly affected the stem girths of maize plants while the interaction effect was not significant in both seasons at 4 and 8WAS. Oka Nsukka gave the biggest stem girth in the early-season while Oka Bende had the biggest stem girth in the late-season although it was not significantly different from the other varieties. The result also indicated that maize stem girth was biggest in plots treated with pre-emergence herbicides (+ hoe weeding at 6WAS) in both seasons compared to the other weed control methods.

Table 3: Effect of maize landraces and weed control methods on maize height, girth and leaf area at 4 and 8 weeks after sowing (WAS) in 2022 cropping season at Igbariam.

	Early Season						**Late season**					
	Height (cm)		**Stem girth (mm)**		**Leaf area (cm^2)**		**Height (cm)**		**Stem girth (mm)**		**Leaf area (cm^2)**	
Treatment	**4WAS**	**8WAS**	**4WAS**	**8WAS**	**4WAS**	**8WAS**	**4WAS**	**8WAS**	**4WAS**	**8WAS**	**4WAS**	**8WAS**
Variety (Var.)												
Oka Abakaliki	65.80	194.70	3.50	8.25	389.80	782.60	63.00	202.00	4.16	8.30	377.80	613.0
Oka Bende	64.00	195.30	4.17	7.92	377.80	783.70	65.30	200.00	3.91	9.30	389.80	637.0
Oka Nsukka	63.20	190.20	3.92	8.33	389.80	790.70	62.20	201.00	3.50	9.00	389.80	643.0
Mean	64.33	193.40	3.86	8.16	385.80	785.66	63.50	201.00	3.85	8.80	385.80	631.0
LSD	NS	NS	0.50	NS	NS	NS	NS	NS	0.48	NS	NS	NS
Weed Control Method (WCM)												
W0	46.90	95.60	2.22	6.33	346.90	715.20	46.40	106.00	2.22	6.20	346.90	540.0
W1	62.30	205.10	2.89	7.89	388.80	765.10	52.30	208.00	2.88	8.30	388.80	564.0
W2	88.00	241.00	5.78	10.00	415.70	851.10	80.60	244.00	5.77	9.60	415.70	717.0
W3	60.00	232.00	4.56	8.44	391.70	811.1	58.60	214.00	4.55	8.00	391.70	590.0
Mean	64.30	193.42	3.86	8.16	385.77	785.62	59.20	193.00	3.85	8.00	385.77	602.0
LSD	6.87	13.18	0.58	0.60	19.53	19.89	8.90	19.60	0.55	3.10	19.81	NS
Interaction												
Var. x WCM	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

NS = Not significant, W0 = Weedy check, W1 = Hoe weeding (at 3 and 6 WAS - weeded control), W2 = Pre-emergence herbicide application + hoe weeding at 6 WAS, W3 = Application of post-emergence herbicide at 3 WAS.

Leaf area: The leaf area among the maize varieties did not differ significantly at 4 and 8WAS in both seasons (Table 3). The result obtained also showed that the weed control methods significantly affected the maize leaf area at 4 and 8WAS in both seasons whereas, the interaction had no significant difference at 4 and 8WAS in both seasons. It was observed that leaf area was highest in plots treated with pre-emergence herbicides (+ hoe weeding at 6WAS) in both seasons.

Effect of maize landraces and weed control methods on maize yield parameters at harvest in the early and late-season planting

Harvested cobs: There was no significant difference in the number of harvested cobs among the different maize varieties in both seasons (Table 4). The number of cobs was only significant in the early season planting with the number of harvested cobs highest in plots treated with pre-emergence and hoe weeded at 6WAS. The interaction effect did not significantly affect the number of harvested maize cobs.

Weight of harvested cobs: The weight of harvested cobs of maize followed similar trend as the number of harvested cobs with regards to the varieties, weed control methods and the interaction effect.

Dehusked cob weight: Dehusked cob weight was significantly different in the late season planting alone while the weed control methods significantly affected the weight of dehusked cobs in both seasons (Table 4). The interaction effect of maize variety and weed control methods was also significant at late season planting alone. In the late-season, Oka Bende gave the heaviest cob weight followed by Oka Nsukka. Maize varieties sown in plots treated with pre-emergence herbicide and hoe weeded at 6 WAS produced the highest dehusked maize cob weight in both seasons.

Grain weight/100 seeds: Oka Nsukka in the early season planting had the highest percentage grain weight per 100 seeds of maize (Table 4). In the late-season planting, it was not significant. Maize varieties in the plots treated with pre-emergence herbicide and hoe weeded at 6WAS, followed by plots where post-emergence herbicides were applied at 3WAS, significantly gave the highest grain weight per 100 seeds in both seasons. However, the interaction effect did not significantly have any effect on the maize grain weight per 100 seeds.

Table 4: Effect of maize landraces and weed control methods on maize number of harvested cobs, weight of harvested cobs, weight of dehusked cob and grain weight/100 seeds of selected maize varieties in 2022 cropping season at Igbariam.

	Number of harvested cobs		Weight of harvested cobs (Kg)		Dehusked cob weight (kg)		Grain weight/ 100 seeds (%)	
Treatment	Early	Late	Early	Late	Early	Late	Early	Late
Variety (Var.)								
Oka Abakaliki	31.67	21.89	1.73	1.40	0.48	0.45	12.52	9.00
Oka Bende	31.67	22.61	1.77	1.00	0.48	0.52	13.61	8.30
Oka Nsukka	31.83	22.61	1.64	1.70	0.44	0.47	14.04	9.20
Mean	31.72	22.37	1.71	1.30	0.46	0.48	13.39	8.80
LSD	NS	NS	NS	NS	NS	0.04	1.21	NS
WCM								
W0	19.22	21.96	1.22	1.20	0.21	0.22	7.81	6.80
W1	31.89	22.33	1.70	1.00	0.38	0.42	10.89	8.30
W2	40.67	22.63	2.17	1.10	0.74	0.73	19.36	8.60
W3	35.11	22.56	1.76	1.10	0.53	0.55	15.50	8.90
Mean	31.72	22.37	1.71	1.10	0.46	0.48	13.39	8.20
LSD	3.88	NS	0.16	NS	0.07	0.05	1.40	5.60
Interaction								
Var. x WCM	NS	NS	NS	NS	NS	*	NS	NS

NS = Not significant, * = Significant at 0.05%, W0 = Weedy check, W1 = Hoe weeding (at 3 and 6 WAS - weeded control), W2 = Pre-emergence herbicide application + hoe weeding at 6 WAS, W3 = Application of post-emergence herbicide at 3 WAS.

Effect of weed control methods and maize cultivars on weed density and biomass at 8 weeks after sowing (WAS) in both cropping season at Igbariam

Weed density: Weed population was not significantly different in both seasons under the maize varieties at 8WAS (Table 5). But the population of weeds was significantly highest in the weedy checks whereas the interaction between the maize variety and weed control methods showed no significant difference.

Weed biomass: The weed biomass followed similar trend as the weed density (Table 5). In both seasons, the weed biomass was not significantly different under the maize varieties planted although the highest weed biomass was found under Oka Abakiliki in the early season while Oka Bende had the highest weed biomass in the late season planting. The highest weed biomass was however found in the weed check plots which produced significantly very high weed biomass.

Table 5: Effect of weed control methods and maize cultivars on weed density and biomass at 8 weeks after sowing (WAS) in 2022 cropping season at Igbariam

Treatments	Weed density		Weed biomass (g)	
	Early season	Late season	Early season	Late season
Variety (Var.)				
Oka Abakaliki	86.40	56.00	163.10	119.60
Oka Bende	89.20	78.80	157.70	125.10
Oka Nsukka	62.80	67.40	143.20	124.20
Mean	79.46	67.40	154.66	122.20
LSD $_{(0.05)}$	NS	NS	NS	NS
Weed Control Method (WCM)				
W0	221.40	175.70	461.6	327.60
W1	42.80	40.8	64.30	35.10
W2	16.10	27.95	27.40	28.20
W3	37.70	28.20	65.30	30.80
Mean	79.50	68.16	154.65	105.43
LSD $_{(0.05)}$	53.95	22.64	45.28	36.24
Interaction				
Var. x WCM	NS	NS	NS	NS

NS = Not significant, W0 = Weedy check, **W1** = Hoe weeding (at 3 and 6 WAS - weeded control), **W2** = Pre-emergence herbicide application + hoe weeding at 6 WAS, **W3** = Application of post-emergence herbicide at 3 WAS.

DISCUSSION

The physical and chemical properties of the soil of the area are an evidence characterized by deep porous soil which is derived from sandy deposits in the coastal plains. The soils of this area are highly weathered, low in mineral reserve and natural fertility (Chikezie *et al*, 2010). Also, the weed flora composition is a reflection of the diversity of weeds in a tropical environment. The general weed composition of the experimental site followed a similar trend as reported by Melifonwu (1994) who noted that broadleaved weed species are usually the most frequent weeds in Southeast Nigeria. This also corroborated the report of Toure *et al.* (2013) and Olayinka *et al* (2020) in class composition weeds for different zones in Nigeria and Africa. This area was largely occupied by broads and a number of grasses which explains why the application of pre- emergence herbicide followed by hoe weeding at 6 WAS controlled the weeds better resulting in better yield of maize in both seasons. The lack of significant differences in the growth and yield parameters of the various maize landraces measured may be an indication that they adapted easily in the environment irrespective of the season when they are planted (Toloraya *et al.,* 2010). However, with regards to the maize grain weight per 100 seeds, Oka Nsukka gave the best yield especially in the early season planting followed by Oka Bende in the early season and Oka Abakaliki in the late-season plantings.

Among the weed control methods used in this study, application of pre-emergence followed by hoe weeding at 6 weeks after sowing provided the best weed control in both seasons thereby increasing the yield of the maize crops. This showed that using the combinations of herbicides and hoe weeding will constantly keep the maize plot weed free. This is similar to the findings of Mahadi, (2011) as he stated that weed competition decreases growth and yield of maize plant.

CONCLUSION

The result from this research suggested that the selected landrace maize cultivars responded positively to the weed control treatments especially 'Oka Nsukka' and 'Oka Bende' in both seasons thus, should be produced more in their localities. Therefore, a combination of pre-emergence herbicide and hoe weeding will always ensure that the weeds are adequately controlled to maximize yield.

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Growth and Yield Responses of two Accessions of Bitter Leaf to Stem Pruning

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K E Y W O R D S

Bitter leaf,
Growth,
Pruning,
Shoot,
Yield.

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A B S T R A C T

A two season (rainy and dry seasons) experiment was conducted to determine the effects of stem pruning on growth and leaf yield of two accessions of bitter leaf in 2021 and 2022 cropping seasons. The experiment was carried out at the Demonstration Farm of the Department of Crop Science and Horticulture, Nnamdi Azikiwe University, Awka, Anambra State, Nigeria. The two accessions (Nimo and Nnewi) received four levels of stem pruning which were no pruning, pruning to 1, 2 and 3 stems. The experiment was laid out as a 2 x 4 factorial in randomized complete block design (RCBD) and replicated three times. The result indicated that stem pruning had significant ($P<0.05$) effect on the growth and leaf yield of bitter leaf. The tallest plants, highest number of leaves, widest stems, highest leaf fresh and dry weight were observed in plants that were pruned to 3 stems while unpruned plants significantly ($P<0.05$) produced the lowest mean values for both growth and leaf yield. Growth and leaf yield did not show significance among the accession though results showed that Nimo accession produced higher number of leaves, tallest plant and highest fresh leaf yield in the two seasons. Combined effect of stem pruning and accessions showed that pruning Nimo accession to 3 stems produced most vigorous plants and highest leaf yield. Considering the results obtained, stem pruning of bitter leaf, especially Nimo accession, to 3 stems was recommended for farmers in Awka since it recorded most vigorous plants and highest leaf yield.

INTRODUCTION

Bitter leaf (*Vernonia amygdalina* Del.) is a vegetable widely grown throughout Africa. It grows primarily in tropical Africa especially in Nigeria, Zimbabwe and South Africa (Faromi, 2003). It is domesticated in parts of West Africa. It belongs to the family, Asteraceae (Okafor, 2002). The crop has been reported to possess high nutritional and medicinal values (Oyeyemi *et al*., 2018). Extracts from bitter leaf have been shown to have anti-bacterial, anti-fungal, anti-plasmodial, anti-cancer, anti-oxidant, anti-diabetic and nephron-protective effects (Ijeh and Ejike, 2012). Other popular medicinal use of bitter leaf includes traditional treatments of diseases such as malaria, infertility, diabetes, gastro-intestinal problems and sexually transmitted diseases (Farombi and Owoeye, 2011). In Nigeria, the leaves are consumed as green leafy vegetables where they are used as soup condiments after washing and boiling to get rid of the bitter taste (Abosi and Raseroka, 2013).

Pruning is a horticultural practice involving the selective removal of certain parts of a plant, such as branches, buds or roots (Nelson, 2017). It increases branches in plants resulting in increased leaf production (Hossain *et al*., 2007). In some cases, pruning is used as a preventive measure to make space for any new seedling or growth. It is important to prune trees and shrubs at the proper time (Maximum Yield Inc, 2019). Pruning focuses more on the removal or reduction of parts of a plant, tree or vine that are not requisite to growth or production and are no longer visually pleasing. Commercial bitter leaf farmers in Anambra State practice coppicing at the onset of rainy season in order to facilitate new shoot and leaf growth (Field Survey, 2019) but there is scarcity of information on the effect of pruning stem to specific number of shoots, at the juvenile stage, on growth and yield of bitter leaf. Earlier preliminary findings (Ndukwe *et al*., 2021) on bitter leaf in the same study area revealed that the crop responds positively to stem pruning although the research was conducted within four months. The objective of this study, therefore, was to ascertain the growth and yield response of bitter leaf to stem pruning.

MATERIALS AND METHODS

Experimental Site

The experiment was conducted at the Teaching and Research Farm of the Department of Crop Science and Horticulture, Nnamdi Azikiwe University, Awka, Anambra State Nigeria. Awka is a tropical rain forest with an average temperature of between 27°C and 30°C. The area is located between latitude 06° 151'N and longitude 07° 081'E, with an average rainfall of 1810.3 mm per annum and a humidity of 75- 80% (GEOMET NAU, 2019).

Sources of Planting Material and Manure: Stem cuttings of two accessions of *V. amygdalina* (Nimo and Nnewi accessions) were collected from commercial farms located at Nimo and Nnewi, respectively. The stems were cut into an average length of 15cm, bearing 3-5 nodes. Poultry manure was collected from battery caged poultry farm in Awka, Nigeria.

Treatments and Experimental Design: Treatments comprised two accessions of bitter leaf (Nimo and Nnewi) and four levels of stem pruning namely no pruning, pruning to one stem, two stems and three stems**.** These treatment combinations were laid out as split plot in randomized complete block design (RCBD) and replicated three times. Blocks were separated from each other with a space of 1 m. Each plot measured 2.5 m by 2.5 m and were separated from each other with a space of 0.5 m.

Land Preparation, Planting and other Cultural Practices: The land was cleared of existing vegetation and ploughed. The soil was raised to beds measuring 2.5 m x 2.5 m. Stem cuttings of 10-15 cm long were planted on the beds at 1 m x 1 m spacing. Unsprouted stems were replaced after four weeks of planting. Blanket poultry manure was applied at 10t/ha to the soil at 20 cm diameter from each plant using ring method of application. Pruning was done at eight weeks after planting, the plants were pruned to one, two and three branches, No pruned plants represented the control. Observational units were the three middle plants in each experimental unit. The main plot was the two accessions of bitter leaf (Nimo and Nnewi accessions) while the sub plot was the levels of pruning (no pruning, pruning to one, two and three stems.

Data Collection and Analysis

Growth data were collected at two weeks interval and comprised height of tallest branch, stem girth of tallest branch and total number of leaves. Height of tallest branch was recorded using a flexible measuring tape while stem girth was recorded with digital vernier caliper. Total number of leaves was obtained by counting the number of fully opened leaves on each branch of the plant. Fresh and fully opened leaves were harvested by picking at 3 weeks interval. All data collected were subjected to analysis of variance following the procedures outlined for the design for split plot experiment RCBD using GENSTAT (2012). Correlation was carried out on some growth and yield parameters by using SPSS (2013).

RESULTS

Main effect of stem pruning and accessions on the height of tallest branch

Plant height in 2021 was significantly ($P<0.05$) influenced by pruning in all the sampling periods except in 11 weeks after planting (Table 1). The tallest plants were produced by plants that were pruned to three branches while shortest plants were observed in plants that were not pruned. In 2022, the shortest plants were observed in plants that were pruned to one stem in all the sampling periods while the tallest plants were produced by plants that were pruned to three branches.

Nimo accession was significantly ($P<0.05$) taller than Nnewi accession in 2021 but in 2022 there was no significant difference in the plant of height of both Nimo and Nnewi accessions (Table 1). However, the mean values of plant height for Nimo accession were higher than the values recorded in Nnewi accessions.

The interaction of bitter leaf accession and stem pruning showed that there were significant ($P<0.05$) difference in all the sampling periods in both 2021 and 2022 cropping seasons (Table 2). The plants that produced the tallest branch was Nimo accession pruned to three stems specifically at 9, 11, 13 and 16 weeks after planting in 2021 season. This trend was repeated in 2022 cropping season. It was also observed that unpruned plants were shortest irrespective of the accession.

Table 1: Main effects of stem pruning and accession on height (cm) of tallest shoot in 2021 and 2022 cropping seasons

	Weeks after planting in 2021				**Weeks after coppicing in 2022**							
Stem pruning	9	11	13	16	10	12	14	16	18	20	23	26
Pruning to 1 stem	36.0	44.0	48.1	56.2	39.3	48.2	55	61.1	61	59.2	62.4	67
Pruning to 2 stems	39.0	44.0	48.2	58.4	41.4	53	64	71.1	67.3	69	71	77
Pruning to 3 stems	42.1	44.0	52.0	77.0	45.3	56	65.4	75.4	73.4	86	97.4	105
No pruning	28.0	27.0	31.0	42.3	42	51.2	59.4	65.2	66	70	75	79
$LSD_{0.05}$	12.6	ns	13.6	16	ns	Ns	ns	12.1	ns	13	14.2	14
Accessions												
Nimo	40	47	52	67.4	44	54.3	63	70.4	69	73	80.4	87.4
Nnewi	30	31	38	50	41	50.2	58.2	65.3	65	69.2	72.4	76.1
$LSD_{0.05}$	9.5	15.1	15	ns	ns	Ns	ns	ns	ns	ns	ns	ns

Table 2: Interaction of stem pruning and accessions of bitter leaf on height (cm) of tallest branch in 2021 and 2022 cropping seasons

		Weeks after planting in 2021				**Weeks after coppicing in 2022**							
Accession	**Stem pruning**	**9**	**11**	**13**	**16**	**10**	**12**	**14**	**16**	**18**	**20**	**23**	**26**
Nimo	Pruning to 1 stem	44	51.4	44	54.1	39.3	47.3	54.2	61.2	60.4	58	61	86.4
	Pruning to 2 stems	43	49.3	54	64	40	55.3	66	73	70	70.2	73	81
	Pruning to 3 stems	49	61.2	68	89	49	60.4	68.4	78.3	75	90.1	112	122
	No pruning	24	26.3	31	40.2	46.1	53.2	63.4	68.4	69	74	77	80
Nnewi	Pruning to 1 stem	22.4	26	29	35.4	39.3	49.1	54.3	60.2	61	61	64.1	68
	Pruning to 2 stems	35	39	43	53	43.3	52.3	62	70	65	67	69	72
	Pruning to 3 stems	40.4	37	49	65.2	42	53	63	70.2	72	81.1	83.1	88
	No pruning	22	27	31	44.4	39	47	55.3	62.4	62.3	68	74	77.2
	$LSD_{0.05}$	15.8	14	18.1	22	ns	ns	ns	16.9	ns	20.3	20.9	20.7

Effects of stem pruning and accession on number of leaves

The number of leaves of bitter leaf was significantly (P<0.05) influenced by stem pruning all through 2021 and 2022 seasons (Table 3). Highest number of leaves was observed in plants that were pruned to three stems in both 2021 and 2022 cropping seasons. This was followed by plants pruned to two stems in all the sampling periods in both cropping seasons. Table 5 also showed that Nimo accession produced higher number of leaves than Nnewi accession in all the sampling periods in 2021 and 2022 seasons. The combined effects of accessions and pruning indicated significant influence on the number of leaves as shown in Table 4. Pruning of Nimo and Nnewi accessions to three branches significantly enhanced the production of highest number of leaves all through the sampling periods in 2021 and 2022 cropping seasons. This was followed by plants pruned to two stems.

Table 3: Main effects of stem pruning and accession on number of leaves in 2021 and 2022 cropping seasons

	Weeks after planting in 2021				**Weeks after coppicing in 2022**							
Stem pruning	**9**	**11**	**13**	**16**	**10**	**12**	**14**	**16**	**18**	**20**	**23**	**26**
Pruning to 1 stem	20	12.1	19.2	35	37.3	35.1	41.1	24.2	27	18.2	20	22
Pruning to 2 stems	34	16.1	27.2	47.3	34.2	53.3	65	34	32	23	26	29
Pruning to 3 stems	43.1	24	44.1	76.2	53.1	76	77	55.1	45	46	87	83.3
No pruning	23.3	13.2	14.4	36.1	40	39.4	48.3	29.2	33.2	25	25.4	28.1
$LSD_{0.05}$	14.7	5.2	14	17.8	16.8	10.2	20.8	12.9	7.8	4.3	11.1	7.8
Accessions												
Nimo	34.3	19	35.3	58.4	52	56.4	67	44	42	33	50.2	49.3
Nnewi	26	14	17.2	40	30.4	45.4	48	27	26.4	23.2	29	32
$LSD_{0.05}$	13.2	ns	ns	28.3	19.7	Ns	ns	ns	13.1	7.4	16.6	15.3

Table 4: Interaction of stem pruning and accessions of bitter leaf on number of leaves in 2021 and 2022 cropping seasons

		Weeks after planting in 2021				**Weeks after coppicing in 2022**							
Accession	**Stem pruning**	**9**	**11**	**13**	**16**	**10**	**12**	**14**	**16**	**18**	**20**	**23**	**26**
Nimo	Pruning to 1 stem	32	15.1	31	47	47.3	38	49	25.1	34	20	21	24
	Pruning to 2 stems	35	17	35.2	55	55.3	60	73	41.1	38.4	29	31	34
	Pruning to 3 stems	46	28	56	88.4	59.1	81.1	86.4	73	56	53	119	110
	No pruning	25	15	19.4	38.3	55.6	47	57.3	36.2	38.4	29	30	30.2
Nnewi	Pruning to 1 stem	7.8	9.1	8	22.1	49.1	32.2	34	23.3	19.2	17	18.1	20.4
	Pruning to 2 stems	33	15.2	19.2	40	52.3	47	55.3	27	25	17	20.3	25
	Pruning to 3 stems	40.3	20.1	32.4	64	53	71	65	37.3	34	38.4	55	57
	No pruning	22	11.4	9.4	34	47	32.1	39.3	22.2	28	21	21	26
	$LSD_{0.05}$	19	7.1	19	26.2	ns	16.4	28.1	19	11.7	6.6	16	12.8

Effect of stem pruning and accession on leaf yield of bitter leaf

The main effect of stem pruning on leaf yield of bitter leaf indicated that stem pruning had significant influence on the total leaf fresh and dry leaf weight in 2021 and 2022 cropping seasons (Table 5). Pruning the stems to three significantly ($P<0.05$) produced highest fresh leaf weight (0.9 t/ha) and dry leaf weight (0.26 t/ha) in 2021. The same trend was repeated in 2022 with highest fresh leaf weight (1.2 t/ha) and dry leaf weight (0.3 t/ha) recorded by plants pruned to three stems. Lowest fresh and dry leaf yield were recorded in either the unpruned plants or plants pruned to one stem. The main effect of accessions showed that Nimo accession consistently produced higher fresh and dry leaf yield than Nnewi accession in both 2021 and 2022 cropping seasons (Table 5).

The interaction of accession and stem pruning had significant ($P<0.05$) influence on the fresh and dry leaf weights of bitter leaf as indicated on Table 6. Pruning the stems of Nimo accession to three stems resulted in highest leaf fresh and dry yield while lowest leaf yield was obtained from Nnewi accession pruned to one stem.

Table 5: Main effects of stem pruning and accession on leaf yield of bitter leaf in 2021 and 2022 cropping seasons

	2021		**2022**	
Stem pruning	**Total leaf fresh weight (t/ha)**	**Total leaf dry weight (t/ha)**	**Total leaf fresh weight (t/ha)**	**Total leaf dry weight (t/ha)**
Pruning to 1 stem	0.4	0.13	0.5	0.14
Pruning to 2 stems	0.5	0.17	0.8	0.2
Pruning to 3 stems	0.9	0.26	1.2	0.3
No pruning	0.41	0.13	0.6	0.17
$LSD_{0.05}$	0.25	0.06	0.2	0.05
Accessions				
Nimo	0.71	0.21	0.9	0.3
Nnewi	0.42	0.13	0.6	0.16
$LSD_{0.05}$	ns	0.07	ns	0.05

The interaction of accession and stem pruning had significant ($P<0.05$) influence on the fresh and dry leaf weights of bitter leaf as indicated on Table 6. Pruning the stems of Nimo accession to three stems resulted in highest leaf fresh and dry yield while lowest leaf yield was obtained from Nnewi accession pruned to one stem.

Table 6: Interaction effects of stem pruning and accession on leaf yield of bitter leaf in 2021 and 2022 cropping seasons

		2021		2022	
Accession	Stem pruning	Total leaf fresh weight (t/ha)	Total leaf dry weight (t/ha)	Total leaf fresh weight (t/ha)	Total leaf dry weight (t/ha)
Nimo	Pruning to 1 stem	0.6	0.16	0.6	0.17
	Pruning to 2 stems	0.7	0.21	0.8	0.23
	Pruning to 3 stems	1	0.31	1.5	0.41
	No pruning	0.5	0.15	0.7	0.2
Nnewi	Pruning to 1 stem	0.2	0.09	0.4	0.12
	Pruning to 2 stems	0.4	0.1	0.7	0.17
	Pruning to 3 stems	0.7	0.2	0.9	0.22
	No pruning	0.3	0.09	0.5	0.14
	$LSD_{0.05}$	0.4	0.1	0.2	0.08

DISCUSSION

Result showed that pruning had significant effect on plant height, number of leaves, stem girth and yield at harvest, with pruning to three stems recording significantly highest mean values for these variables. Unpruned plants produced shortest plants; this could be as a result of competition for resources especially solar radiation as a result of many branches produced by the unpruned plants. Pruning to three stems must have enhanced solar distribution within the canopy thereby increasing their photosynthetic capacity and quantum yield of leaves as stated by Hossain, Amru and Normaniza (2017). More vigorous plants and higher leaf yield were produced by Nimo accession, indicating that Nimo accession had easier adaptation to Awka environment (location of the experiment) than Nnewi accession. This is in agreement with the findings of Ndukwe *et al*. (2021). Nimo and Awka belong to the same agroecological zone in Anambra State.

CONCLUSSION

The study concluded that stem pruning of bitter leaf especially pruning to three stems good and was recommended for adoption to farmers because it produced most vigorous plants and the highest leaf yield throughout the sampling periods. Nimo accession was recommended as promising planting material for bitter leaf farmers within Awka metropolis and environs.

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Soil Physicochemical Properties, Growth and Development of Sweet Melon (*Cucumis melo* L.) as Influenced by some Organic Amendments at Awka, South Eastern Nigeria

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ABSTRACT

A study on the soil physicochemical properties and agronomy of sweet melon (Cucumis melo L.) as influenced by different organic amendments was conducted at the Soil Science and Land Resources Management Research Farm, Faculty of Agriculture, Nnamdi Azikiwe University, Awka. The experiment was laid out in randomized complete block design (RCBD) with five treatments, replicated three times. The treatments were: Bat manure (10t/ha), Pig manure (10t/ha), Dry neem leaves (10t/ha), Poultry manure (10t/ha), and a control (0t/ha). Data collected were subjected to Analysis of Variance (ANOVA) using Genstat4th edition statistical software. Means were separated usingFisher's Least Significant Difference (F-LSD) at 5% probability level. The results obtained showed that the application of organic amendments had significant effects on some soil physical properties but did not significantly affect any of the chemical parameters tested. Meanwhile, some growth parameters studied as well as the yield component showed significant differences among the various treatments at 3, 6 and 9weeks after planting (WAP). Bat Guano recorded the highest values for most physical properties, growth parameters and fruit weight, and is closely followed by poultry manure. Though soil chemical properties did not show statistical significant differences, application of organic amendments resulted to increased value of soil organic carbon, Total N, pH, CEC, and exchangeable bases. Bat manure though scarce, is recommended for farmers to be used in the production of Sweet Melon in the study area for higher yield and an alternative manure source for sustainable soil fertility management.

INTRODUCTION

Organic farming has become an essential priority worldwide in view of the growing demand for healthy and safe food, long-term sustainability and concerns regarding the environmental pollution related to the indistinctive utilization of chemical fertilizers, (Al-Erwy *et al*., 2016). Over the years, use of synthetic materials in crop production has been a common practice globally. The attendant detrimental effects of the chemicals used in the formulation of these synthetics on animal and human health as well as the environment has made researchers to look out for a better agronomic practice that would not only improve productivity but at the same time sustain a healthy environment (Onunwa, *et al*., 2021).Organic materials are very important soil amendments that sustain the productivity of soils in tropical and subtropical areas where there is low soil organic carbon (SOC) content and lower input of organic materials (Zheng *et al*., 2016). Using organic wastes including Poultry manure, Bat guano (bat manure), Pig waste and dry neem leaves as soil amendments is an ideal way to maintain soil organic matter, improve soil quality and provide nutrients essential to plants (Ghasem *et al*., 2014).

Sweet melon (*Cucumis melo* L.) fruit is one of the most important and popular fruit vegetables grown in Egypt; it is used mainly as a desert and refreshing fruit. It is rich in bioactive compounds such as phenolics, flavonoids and vitamins as well as carbohydrates and minerals (especially potassium). In addition, it is low in fat and calories (about 17 kcal/100g). It has a large amount of dietary fiber (Tamer *et al*., 2010). This study was designed to investigate the effect of selected organic amendments on soil physicochemical properties as well as the growth and yield of sweet melon (*C. melo* L.). The specific objectives were to determine: the effect of organic amendments on soil physical and chemical properties; the effect of organic amendments on the growth and yield of sweet melon '*C. melo* L.'.

MATERIALS AND METHODS

This study was carried out at the Soil Science and Land Resources Management Research Farm, Faculty of Agriculture, Nnamdi Azikiwe University, Awka, Anambra state. Awka is located within Latitudes 06°14.0'N – 06°15.95'N, and Longitudes 07°6.0'E – 07°7.8'E. It has a bimodal rainfall system which lasts between March and October, with a short break around July/August called August break. The rainfall ranges from 1,500 to 2,000mm per annum. The temperature ranges from 20 to 35°C, while the relative humidity ranges from 63% to 88%. (Ezenwaji *et al*., 2014).

Sweet melon *(C. melo* L.*)* was imported from East-West Seed International ltd, Thailand. Guano was collected from empty bat infested buildings at Ifite-Ogwari, Anambra State. Poultry manure was gotten from Food Soldiers Farms; Pig waste was collected from Animal Science Research farm; Neem leaves were harvested fresh from neem plants (and were dried properly under sunlight) all within Nnamdi Azikiwe University, Awka, Anambra State.

The experiment was laid out in randomized complete block design (RCBD) with five treatments, replicated three times. The treatments were: Bat manure (10t/ha), Pig manure (10t/ha), Dry neem leaves (10t/ha)., Poultry manure applied at 10t/ha and a control (0t/ha).

Land area of about 0.49ha was mapped out using measuring tape, rope and pegs. The site previously cropped to corn, was cleared manually and the residue turned into the soil. Melon seeds were planted directly to the soil at the rate of one seed/hole and at a spacing distance of 30cm x 45cm.Weeds were controlled by hand picking every two weeks.

Soil Sampling and Analysis

A total of 6 disturbed and 6 undisturbed soil samples were collected at a depth of 0-15cm from different location at the experimental field using auger and core samplers. The disturbed samples were bulked together to obtain a composite sample while the 6 undisturbed samples were used for the determination of bulk density, moisture content and hydraulic conductivity. The post harvest soil samples were collected at designated points. Both samples were air dried and passed through a 2mm sieve and analyzed for both physical and chemical properties.

The following analyses were carried out on the samples: Moisture content was determined using gravimetric method (Jalota *et al*., 1998); Particle size analysis was done using Bouyoucos hydrometer method as described by Gee and Bauder (1986); Soil bulk density was determined using core method as described by Blake and Hartage (1986); Organic carbon was determined by Walkley and Black wet oxidation method as outlined by Nelson and Sommers (1982); Exchangeable bases (K, Ca, Na, and Mg) were extracted with 1N NH_4OAC buffered at pH 7.0 (Thomas, 1982). The amount of Ca and Mg were determined using Ethylene Diamine Tetra-Acetic (EDTA) titration method while potassium and sodium were determined by flame photometer (Rhoades, 1982); Available P was determined using Bray 2 extraction method (Bray and Kurtz, 1945); Exchangeable acidity was extracted with 1N KCL (Thomas 1982) and was determined by titration method using 0.005N NaOH and phenolphthalein as indicator; Total nitrogen was determined using macro kjedahl method (Bremer and Mulvancy, 1982); Soil pH was determined potentiometrically in a slurry system using an electronic pH meter (Mclean 1982); The base saturation was calculated mathematically as: TEB/ECEC × 100/1

Where TEB = Total Exchangeable Bases (Ca, Mg, K and Na); and ECEC = effective cation exchange capacity

Effective Cation Exchange Capacity (ECEC) was calculated as the summation of the exchangeable bases (Ca, Mg, K, and Na) and exchangeable acidity.

Plant data were collected from the experimental unit on the following parameters; vine length (cm), number of leaves and number of braches per plant at 3, 6 and 9WAP; as well as the plant yield (fruit weight)(t/h).

Statistical Analysis

Data collected were subjected to analysis of variance (ANOVA) using Genstat4th edition (2011); means were separated using Fishers Least Significant Difference (F-LSD) at 0.05 probability level.

RESULTS AND DISCUSSION

Effect of Organic Amendments on the soil physical properties

Table 1 showed the effects of organic amendments on the physical properties of the soil. Observed result indicated that there was a significant difference in the physical parameters tested. The parameters as portrayed by the result were in this order: Bulk density (g/m^3) followed the order: Bat manure, BM (1.52) = Control, C (1.52) > Poultry manure, PM (1.50) > Pig waste, PW (1.49) >Neem Leaves, NL (1.46). Porosity followed the order: NL (45.09) > PW (43.90) > PM (43.52) > BG (42.64) > C (42.61). Soil Moisture content followed this order: BM (46.12) > PM (45.85) > C (45.24) > NL (45.13) > PW (44.93) and hydraulic Conductivity (Ksat) was in this order: C (68.20) > BM (65.80) > NL (57.20) > PW (55.30) > PM (54.50). This result obtained could be attributed to the addition of organic matter to the soil as a result of the amendments used. This finding corroborates the finding of Eilín and McDonnell (2012), who observed that organic amendments played important and multi-faceted role in soil by influencing soil structure and all its associated properties. Eloi *et al*. (2022) also reported that *Tithonia diversifolia* fresh biomass and poultry manure (PM) lowered the soil bulk density, increased soil total porosity and water holding capacity.Only Ksat had significant interaction effect among all the treatments. Every other parameter tested did not show any interaction effect.

Table 1: Effect of organic Amendments on Soil Physical Properties

	Physical properties			
Manure type (MT)	BD g cm-3	Porosity	MC (%)	Ksat mm hr
Bat Guano	1.52	42.64	46.12	65.8
Neem Leaves	1.46	45.09	45.13	57.2
Pig Waste	1.49	43.9	44.93	55.3
Poultry manure	1.5	43.52	45.85	54.5
Control	1.52	42.61	45.24	68.2
LSD (0.05)	0.04	1.64	0.78	34.42

BD = Bulk Density, MC= Moisture Content, Ksat = Saturated Hydraulic Conductivity

The chemical parameters tested (Table 2) did not show any significant differences/variations and there was no interaction effect. However, it was observed that application of organic amendments increased the value of most chemical parameters measured as against the control. This observation is in agreement with the findings of Kaur *et al*. (2005) who reported that the application of organic manures improved soil organic carbon content.

Table 2: Effect of organic Amendment on soil chemical properties

	Soil Chemical Properties (Cmol/kg)											
Manure type (MT)	**Na+**	**Ca2+**	**Mg2+**	**K+**	**TEA**	**CEC**	**%BS**	**Al3+**	**H+**	**pH**	**%TN**	**%OC**
Guano	0.39	4.22	1.48	1.59	0.06	6.24	98.8	0.01	0.05	6.1	0.21	1.8
Neem	0.99	4.11	1.33	1.47	0.07	7.96	99.1	0.02	0.05	6.05	0.11	0.85
Pig	0.52	4.67	1.88	2.08	0.05	9.21	99.35	0.01	0.04	6.1	0.22	1.8
Poultry	0.38	4.27	1.36	1.66	0.06	7.76	99.15	0.01	0.05	6.1	0.2	1.7
Control	0.13	4.1	1.32	0.51	0.07	5.38	98.78	0.02	0.05	6	0.09	0.8
LSD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

NS = Not Significant

Table 3 showed the effect of organic amendments on the number of leaves, vine length, number of branches. Observed data indicated that there was significant difference in the number of leaves at 3 and 6 weeks after planting (WAP); significant difference in the vine length at 6 and 9 WAP; and significant difference in the number of branches at 6 and 9 WAP. Meanwhile, at 9WAP, number of leaves did not show significant difference; at 3WAP, vine length did not show significant difference and at 3WAP, number of branches did not show significant difference.

For the number of leaves, at 3 WAP, Guano was the highest (43.67) while control was the least (33.58). At 6WAP, guano also had the highest value (62.50) while control had the least (46.08). For Vine Length, at 6WAP, Guano was the highest (90.83) while control was the least (84.08 and at 9WAP, poultry was the highest (154.00) while control was the least (141.33). For the number of branches, at 6WAP, Guano = Neem = Poultry were the highest (5) while control was the least (3.67) and at 9WAP, guano was the highest (8.17) while PW was the least (6.67). The result obtained indicated that guano manure had the highest values among other treatments. This could be as a result of higher solubility of the guano amendment in the soil where mineralization takes place as compared to other soil amendments studied. These results corroborated the reports by Mlay and Sagamiko (2008) and Thi *et al*. (2014) that the use of bat guano had a positive influence on plant growth.

Table 3: Effect of Organic Amendments on number of leaves, vine length and number of branches at 3, 6 and 9 weeks after Planting

	Sweet melon											
Treatments	**Number of leaves**				**Vine length (cm)**				**Number of branches**			
Organic Amend.	3WAS	6WAP	9WAP	Mean	3WAP	6WAP	9WAP	Mean	3WAP	6WAP	9WAS	Mean
Guano	43.67	62.5	112.3	72.82	37.83	90.83	153.67	94.11	2	5	8.17	5.06
Neem	42	57.17	103.7	67.62	38	87.83	151	92.28	2	5	7.17	4.72
Pig	41.17	53.67	99.3	64.71	38.5	85.33	146	89.94	2	4.33	6.67	4.33
Poultry	43.5	59.33	126.8	76.54	38.5	90.5	154	94.33	2	5	7.67	4.89
Control	33.58	46.08	78.9	52.85	38.08	84.08	141.33	87.83	2	3.67	6.75	4.14
LSD (0.05)	1.86	1.76	NS		NS	1.49	0.48		NS	0.51	0.83	

Table 4 showed the effect organic amendments on sweet melon growth parameters.It was only the percentage emergence and yield (fruit weight) that significantly varied among the parameters measured. Fruit weight was in this order: Guano (13t/ha) = Poultry (13t/ha) >Neem (11.5t/ha) > Pig waste (11.2t/ha) > Control (10.2t/ha).This could be an indication that the growth parameters measured were not significantly affected by the various organic amendments. According to Ambouta *et al*. (2020), bat guano essentially improved the availability of nutrients in the soil and increased the growth and yield of vegetable crops. They also opined that plots treated with bat guano gave highest yields compare to the control.

Table 4: Effect of organic Amendment on sweet melon fruit circumference, fruit length, percentage emergence, fruit weight, number of fruits per plant and days to edible maturity.

			Sweet melon			
Manure type (MT)	**FC (cm)**	**FL (cm)**	**% EM**	**FW (t/ha)**	**NF**	**DEM**
Guano	35.5	20.5	90.5	13	4.17	82.83
Neem	38.5	20.5	76.2	11.5	3.67	85.67
Pig	37	20	90.5	11.2	3.67	85.33
Poultry	41	20.5	92	13	4	85.67
Control	36.75	18.25	89.1	10.2	3.83	84.08
LSD (0.05)	NS	NS	6.44	1.1	NS	NS

NS = Not Significant, FC = fruit circumference, FL = fruit length, %EM = percentage emergence, FW = fruit weight, NF = number of fruits per plant, DEM = days to edible maturity

CONCLUSION AND RECOMMENDATION

The application of selected organic amendments at 10t/ha each significantly influenced Soil bulk density, moisture content and hydraulic conductivity but had no significant effect on the chemical parameters tested possibly due to the short period the experiment lasted or the rate of amendment application was lower than could affect the chemical parameters. The selected Organic amendments used, positively influenced some of the plant parameters assessed and the yield of Sweet Melon. It could therefore be recommended that Sweet Melon farmers in the study area should farm with Bat Guano at 10t/ha for higher yield and sustainable soil fertility management.

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SUB-THEME 2

CLIMATE SMART AGRICULTURE AS A SUSTAINABLE RESPONSE TO CLIMATE CHANGE

Adoption of Sustainable Farming Practices amidst Climate Change Incidence by Crop Farmers in Ebonyi State, Nigeria

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K E Y W O R D S

Sustainable Agriculture,
Climate Change,
Crop Farmers,
Yield and Output

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A B S T R A C T

Sustainable agriculture amidst climate change incidence in Ebonyi State, Nigeria was examined. A multi-stage sampling was used to select 140 crop farmers who were administered with questionnaires. Data collected were analysed using descriptive statistics, logit model and the local average treatment model. Results shows that the crop farmers were married (72.1%), more of males (70.7%), relatively educated (Mean = 12) and were in their productive age (51) years. Crop rotation (94.3%), bush fallowing (76.4%), shifting cultivation (98.6%), multiple cropping (100%), and erosion control measures (69.3%) were some of the sustainable agricultural practices adopted by the crop farmers in the State. About (94.3%) of the crop farmers adopted these practices against 6% that did not adopt. Age, sex, education, farm size, extension contacts, and farming experience were the major determinants of sustainable agricultural practices of the farmers. The adoption and use of sustainable farming practices increased land yield and output by (910.03%) and (1211.02%) amidst climate change manifestations. Farmers were recommended to adopt and practice sustainable farming practices to improve crop yield, output and land productivity in the State. This will ensure increased food production and security in the State.

INTRODUCTION

The challenge for agriculture to meet the World's increasing demand for food in a sustainable way is still far-fetched. This could be credited to the adverse effects of climate change and declining agricultural farm practices among the crop farmers. Climate change is one of the most serious threats to Nigeria agricultural sector and food security; arising from its sensitivity (Warsame, Sheik-Ali, Ali, and Sarkodie, 2021). For instance, higher temperature lowers the yield of the desirable crops, while encouraging weeds and pests' proliferation and changes in precipitation patterns increase the likelihood of short-run crop failure and long-run production declines, thus its variability create a huge challenge for crop production (Zhai, Song, Qin, Ye, and Lee, 2017). All over the world, issues related to climate change have become a major concern especially as it relates to sustainable agriculture. This is because climate change is seen to be causing serious challenges to the development of agriculture, food security and biodiversity (Osborne and Wheeler, 2013). Farming activities especially those dependent on rain-fed, rely on favourable climate conditions to be productive and are at risk under a changing climate especially if it comes with adverse conditions. Climate change affects food availability, access, and nutritional quality (Raju, 2019). As long as agriculture remains a soil-based industry, climate change will continue to cause major havoc in relation to farm yield, crop output and land productivity. However, increases in farm productivity are likely to be attained through sustainable farming practices (SFP) which ensures increase crop growth, and land productivity of the farmers (Onyeneke, Amadi, Njoku, and Osuji, 2021).

Understanding the principles of SFP can help farmers improve on their farm operations and maintain productive and profitable soil both now and for future generations. SFP is the application of soil management techniques that support plant growth without degrading the soil for further use. It involves the application of soil management practices that sustain food crop production in the midst of climate change and adverse atmospheric weather conditions. The relevance of SFP to agriculture includes the maintenance of soil productivity and economic viability over time without been depleted while maintaining and meeting the food demands of the present and future generations along changing climates and weather conditions (Onyeneke, Nwajiuba, Tegler, and Nwajiuba, 2020). It is the adoption of proven land use and crop management strategies that enable crop farmers to maximize the economic and social benefits of the soil, enhance ecological support and maintain a balanced soil ecosystem. Managing our soils sustainably is very crucial for agricultural production and post harvest of crops as climate change occurs (Adeagbo, Ojo, and Adetoro, 2021). SFP improves the fertility of degraded and marginal soils for long term benefits and protects the soil from degredation, increases its nutrients (with locally sourced products from farm, such as recycled crop residue and animal waste products) used for crop growth. SFP includes the use crop rotation, organic manure, and minimum tillage, erosion control, avoiding traffic on wet soils and maintaining soil cover with plants and/or mulches. It also involves the combination of soil fertility treatment such as application of mineral and organic fertilizers with soil and water conservation measures such as implementation of agronomic principles, soil management and physical measures such as contour ridging, terracing, tied ridges or providing ground cover through mulching, use of leguminous plants and crop residues (Agovino, Casaccia, Ciommi, Ferrara, and Marchesano, 2019). However, considering the interplay of climate change and sustainable agriculture in Ebonyi State in recent past, crop production in the State has fared poorly and unproductive exacerbating the farmers economic returns, yield, output and productivity of the land. This has created a huge gap in knowledge and empirical literature. The objectives of the study include; identify the socio-economic characteristics of the farmers, types of sustainable farming practices, examine the adoption levels of sustainable farming practices, determinants of sustainable farming practices, and impact of sustainable farming practices on land yield and output of farmers.

MATERIALS AND METHODS

The study was conducted in Ebonyi State, Nigeria. The State is made up of 13 Local Government Areas with Abakaliki as its capital. According to the National Population Commission, the State population was estimated to be 2,176,947 people in 2006 (National Population Commission, 2007). The total land area is about 5,533 km^2 with *Latitude*: 6°10' 40.7028" and *Longitude*: 7°57' 33.4296". Temperature ranges around 17^{0c} while precipitation is about 2000mm. Multi-stage sampling technique was employed for sample selection. In the first stage, four local government areas (LGA's) were randomly drawn from each of the agricultural zones of the state; (Ebonyi North, Ebonyi South, and Ebonyi Central), to make 12 LGA's. In the second stage, two communities were randomly selected from the LGAs, making a total of 24 communities. In the third stage, two villages were randomly picked from the selected communities giving 48 villages. The fourth stage had 4 crop farmers randomly selected, giving a total of 192 farmers. Primary data was collected for the study. The survey instrument (questionnaire) was used for primary data collection. It was prepared following the specific objectives of the study and was administered in person to the sampled respondents, but only 140 questionnaires were found useful for data analysis. Data were analysed using mean, frequency and percentage, Logit model and Local Average Treatment Effect (LATE Model). The Logit model is expressed as follows;

Log (P/1-P) = F (X_i, B) + e --- --- --- eqn. 1

Where:
P = Probability of adoption of SFP, while (1− P) is the probability of non-adoption of SFP.
B = Vector of estimated parameter
X_i = Independent variables considered, which include;
X_1 = Age of farmer (Years)
X_2 = Sex of farmer (Male =1, 0 = Female)
X_3 = Education (No of years spent in school)
X_4 = Household size (No. of persons)
X_5 = Net farm income (Naira)
X_6 = Farm size (Ha)
X_7 = Return from off farm activities (Naira)
X_8 = Distance of farm (Km)
X_9 = Labour supply (Mandays)
X_{10} = Cost of land improvement practices (Naira)
X_{11} = Extension contacts (No. of visits)
X_{12} = Farming experience (No. of years spent on crop production)
e = error term

The LATE model was specified as follows;

$$E\ (y_1 - \frac{y_0}{d_1} = 1) = LATE = \frac{cov(y,z)}{cov\ (d,z)} \quad \text{--- --- --} \quad \text{eqn. 2}$$

$$= \frac{E\left(\frac{y}{z}=1\right)-E(\frac{y}{z}=0)}{E\left(\frac{d}{z}=1\right)-E(\frac{d}{z}=0)}$$

$$= \frac{E(y_i*(z-E(z_i)}{E(d_i*(z-E(z_i)}$$

$$= \left(\frac{\sum_{i=1}^{n} y_i z_i}{\sum_{i=1}^{n} z_i} - \frac{\sum_{i=1}^{n} y_i(1-z_i)}{\sum_{i=1}^{n}(1-z_i)}\right) \text{X} \left(\frac{\sum_{i=1}^{n} d_i z_i}{\sum_{i=1}^{n} z_i} - \frac{\sum_{i=1}^{n} d_i(1-z_i)}{\sum_{i=1}^{n}(1-z_i)}\right)\text{-----} \qquad \text{eqn. 3}$$

Specifying LATE model components,

$$\text{ATE} = \frac{1}{n}\sum_{i=1}^{n} i \ \frac{(d_i-p(X_i)y_i}{p\ (X_i)(1-p(X_i)}$$

$$\text{ATE1} = \frac{1}{n1}\sum_{i=1}^{n} i \ \frac{(d_i-p(X_i)y_i}{(1-p)(X_i)}$$

RESULTS AND DISCUSSION

Socio-economic Characteristics of Farmers

The socio-economic characteristics of the farmers are presented in Table 1. The mean age of the farmers is 51 years. This implies that the crop farmers were in their productive age. This could have a tremendous positive influence on crop production and efficiency of resource utilization. According to the Table, 70.7 percent of the farmers were males while the remaining 29.3% were females. This implies that Nigeria agriculture is still male dominated based on the fact that men are bread winners and takes full responsibility in providing for their love ones and families at every given time (Ahmad, Jiang, Majeed, and Raza, 2020). Majority of the farmers, 72.1 percent were married with children which is a significant indication of high family labour availability utilized in the farming business (Agovino *et al*., 2019). The mean household size was 7 persons. This implies that the household size was relatively large and therefore could enhance production efficiency of the crop farmers since rural households rely more on members of their households than hired labourers who charge outrageous wages (Ahsan, Chandio, and Fang, 2020). The mean years of educational attainment were 12 years. This implies that majority of the farmers had secondary education which depicts that the farmers could read and write and able to understand farm production principles and takes critical decisions concerning their farming enterprises (Osuji, Okwara, Essien, Agu, and Oguegbuchulam, 2019). Majority of the farmers 70.7% had farming experience ranging from 11-20 years and the mean farming experience was 17 years. This means that the farmers were experienced in the farming enterprise which might considerably reduce inefficiency in production. Farming experience of a farmer increases his production efficiency and helps him in overcoming climate change incidence and adoption of improved production techniques. The mean extension contact of the farmers was 6.2; this implies that the farmers were visited 6 times in the cropping season. This implies that the household farmers were exposed to improved farm agricultural practices, innovations and their resultant benefits (Zhai *et al*., 2017). The mean farm size was 3.06; this implies that majority of the farmers in the area cultivated on relatively large scale farmlands which is known to improve yields, outputs, land productivity and income of the farmers. Large farm size also accommodates climate change adaptations and adoption of new farming practices (Osuji *et al*., 2019). The Table reveals that majority 92.9 percent of the farmers made use of family labour compared to 4.3 percent of the farmers who used hired labour in their farm operations. This finding shows that a greater percentage of the respondents used family labour due to the high costs charged by most labourers.

Table 1: Socio-economic characteristics of farmers

Variables	Frequency	Percentage	Mean
Age			51.0
20 – 29	5	3.6	
30 – 39	19	13.6	
40 – 49	16	11.4	
50 – 59	83	59.3	
60 – 69	12	8.6	
70 – 79	5	3.6	
Sex			
Male	99	70.7	
Female	41	29.3	
Marital Status			
Married	101	72.1	
Single	8	5.7	
Separated	2	1.4	
Divorced	10	7.1	
Widow/Widower	19	13.6	
Household Size			7.2
1 – 5	52	37.1	

6 – 10	81	57.9	
11 – 15	7	5.0	
Education			12.0
0	10	7.1	
1 – 6	44	31.4	
7 – 12	70	50.0	
13 – 18	16	11.4	
Farming Experience			17.0
1 – 10	11	7.9	
11 – 20	99	70.7	
21 – 30	10	7.1	
31 – 40	16	11.4	
41 – 50	4	2.9	
Extension Contact			6.2
1 – 4	6	4.3	
5 – 9	131	93.6	
10 – 14	3	2.1	
Farm Size			3.06
0.01 – 1.00	5	3.6	
1.01 – 2.00	2	1.4	
2.01 – 3.00	2	1.4	
3.01 – 4.00	131	93.6	
Sources of Labour			
Family labour	129	92.9	
Hired labour	6	4.3	
Both labours	5	3.6	

Source: Field survey data, 2022

Types of Sustainable Farming Practices of Farmers

The various types of sustainable farming practices of the farmers are shown in Table 2. The Table showed that all the crop farmers adopted organic manure and multiple cropping. Organic manure is largely practiced by arable crop farmers to improve the fertility of the soil and productivity of the land. On the other hand, multiple cropping is mainly practiced to avert the risks of total crop failure occasioned by climate change (Roco, Bravo-Ureta, Engler, and Jara-Rojas, 2017). Multiple cropping is further practiced to accommodate one type of crop or the other per cropping season. Similarly about 98.6, 76.4, and 94.3 percent of the farmers adopted shifting cultivation, bush fallowing and crop rotation respectively. Shifting cultivation and bush fallowing are soil sustainable farming practices used to improve the fertility of the soil and enhance crop productivity of the farmers. However these soil management techniques are rarely practiced by crop farmers due to land scarcity and tenure systems available to the farmers (Samuel, Seth, and Edward, 2021). Consequently, a cross section of the farmers adopted mulching 91.4 percent, planting of leguminous/cover crops, 77.9 percent, erosion control measures, 69.3 percent and minimum/zero tillage, 80.7 percent respectively. These sustainable farming practices are generally used to control soil erosion, mitigate climate change and reduce water run-off in most farmlands (Saalu, Oriaso, and Gyampoh, 2020). Again, another section of the famers adopted alley cropping 62.9 percent, crop residue recycling 86.4 percent and mixed farming, 97.1 percent respectively. These practices help in increasing the farm productivity of the farmers, thus leading to an increase in income of the crop farmers. Furthermore, the farmers in the area adopted liming 42.1 percent, taungya farming 32.1 percent, contour cropping 26.4 percent and strip cropping 18.8 percent respectively. Liming is practiced by most crop farmers to reduce the acidity of the soil. Taungya farming improves soil fertility which enhances crop yield and productivity of the farmers (Roco *et al*., 2017). Contour and strip cropping on the other hand are used by crop farmers on slope farmlands to reduce the risks of water run-off and soil loss.

Table 2: Types of sustainable farming practices of farmers

Types of SFP	Frequency	Percentage
Contour Cropping	37	26.4
Strip Cropping	26	18.8
Crop Rotation	132	94.3
Planting of Cover crops	109	77.9
Crop Residue Recycling	121	86.4
Use of Organic Manure	140	100
Use of Mulching	128	91.4
Alley Cropping	88	62.9
Erosion Control Measures	97	69.3
Multiple Cropping	140	100
Minimum/Zero Tillage	113	80.7
Mixed Farming	136	97.1
Liming	59	42.1
Taungya Farming	45	32.1
Bush Fallowing	107	76.4
Shifting Cultivation	138	98.6

Source: Field survey data, 2022

Adoption of Sustainable Farming Practices

The adoption of sustainable farming practices of farmers is shown in Table 3. The Table shows that about 94.3 % of the farmers adopted the sustainable agricultural practices introduced to them as against the 6% that did not adopt. This implies that majority of the farmers practiced the agricultural practices exposed to them thus, leading to increased farm yield, output, land productivity and income of the farmers (Osuji *et al*., 2019). The lesser percentage that did not adopt may be due to ignorance and unwillingness to adopt such sustainable practices.

Table 3: Adoption of sustainable agricultural practices

Adoption of SFP	Frequency	Percentage
Adopted	132	94.3
Non-Adopted	8	5.7

Source: Field survey data, 2022

Determinants of Sustainable Agricultural Practices of Crop Farmers

The estimated determinants of sustainable farming practices of crop farmers are presented in Table 4. The chi (χ^2) was highly significant at 1 percent and this confirms the fitness of the model. The coefficient of age was positive and highly significant at 1 percent level; implying a direct relationship with sustainable farming practices of farmers. This implies that young farmers are more receptive and eager to try out new practices and in responding to climate change (Khanal, Wilson, Hoang, and Lee, 2018). The coefficient of sex was positive and significant at 5 percent level; implying a direct relationship with sustainable farming practices. The positive value denotes that male farmers have greater probabilities of engaging in sustainable farming practices compared to their female counterparts. The coefficient of education was positive and highly significant at 1 percent level indicating a direct relationship with sustainable farming practice. This implies that education increases the ability of the farmers to adopt new technologies. Thus, the level of farmers' education has profound effect on technology adoptions and climate change mitigations (Lenis, Liverpool-Tasie, and Charuta, 2020). The coefficient of net farm income was positive and significant at 5 percent probability level, indicating a direct relationship with sustainable farming practices. This implies that any increase in net farm income increases the adoption of sustainable farming practices. Increase in net farm income empowers farmers to adopt more sustainable soil practices and procurement of agricultural inputs (Mahmod and Beeching, 2018). The coefficient of farm size was positively related to sustainable farming practices and was significant at 1 percent level. This implies that a unit increase in farm size of the farmers will lead to a corresponding increase in the adoption of sustainable farming practices. Larger farm sizes drive farmers to adopt sustainable agricultural practices and purchase of more production inputs. The coefficient of cost of land improvement practices was negatively related to sustainable farming practices and significant at 5 percent probability level. Thus, this indicates an inverse relationship with sustainable farming practices. This implies that any increase in the cost of land improvement practices will lead to a decrease in the adoption of sustainable agricultural practices. High cost of land management practices deters farmers especially those in rural areas from adopting improved soil practices (Mulinya, 2017). The coefficient of the extension contacts was positive and highly significant at 1 percent level, indicating a direct relationship with sustainable farming practices. This implies that a unit increase in extension contacts will lead to a unit increase in the adoption of sustainable farming practices. Extension contacts engender innovative effectiveness, knowledge transfer, information dissemination and adoption drive of the farmers (Samuel *et al*., 2021). The coefficient of farming experience was positively related to sustainable farming practices and significant at 1 percent level. This implies that an increase in farming experience of farmers will lead to a corresponding increase in the adoption of sustainable farming practices. Experience farmers are generally better and knowledgeable enough to access the relevance of new of technologies through interaction with other farmers and the outside world (Mupakati and Tanyanyiwa, 2017).

Table 4: Determinants of sustainable farming practices of crop farmers

Variables	Parameters	Coefficients	t-values	Std Error
Constant	b_o	0.0725	2.5008**	0.0289
Age of farmer	b_1	0.7550	4.0012***	0.1886
Sex of farmer	b_2	0.8923	2.0406**	0.4373
Education	b_3	0.7411	3.7111***	0.1997
Household Size	b_4	-0.9791	-0.0503NS	19.465
Net farm income	b_5	0.5702	1.8881**	0.3019
Farm size	b_6	0.0991	3.0019***	0.0330
Return from off farm activities	b_7	0. 4402	1.1116NS	0.3960
Distance of farm	b_8	0.9044	0.5019NS	1.8019
Labour supply	b_9	0.1883	1.2091NS	0.1557
Cost of land improvement practices	b_{10}	- 0.6065	-2.0905**	0.2901
Extension contacts	b_{11}	0.9121	3.7110***	0.2457
Farming experience	b_{12}	0.7738	4.9529***	0.1562
LR (χ^2)		171.07***		
Log likelihood		186.03		
Pseudo (R^2)		0.8710		
N		140		

Source: Field survey data, 2022 Significant at ***1% and **5%

Impacts of Sustainable Farming Practices on Land Yield and Output of Farmers

The impact of sustainable farming practices on land yield and output of farmers is presented in Table 5. The table reveals that the propensity score matching (PSM) and the inverse propensity score weighing (IPSW) estimates gave 42.6401 and 22.0100 respectively. These estimates fail to identify the actual casual effect of the adoption and use of sustainable agricultural practices. Hence, they are declared inconclusive and imply the existence of non-compliance. The non-compliance here means that there are farmers who will never adopt or use sustainable agricultural practices. Thus the LATE model becomes an appropriate tool in reducing non-compliance issues. From the results, the LATE (WALD) and LATE (IV) estimates gave 9.1003 and 12.1102 and were highly significant. This implies that the adoption and use of sustainable agricultural practices amidst climate change excesses increased land yield and output by 910.03% and 1211.02% (Dokic, Matkovski, Jeremic, and Duric, 2022). This further implies that the higher the adoption and use of sustainable agricultural practices, the higher the increase in land yield and output of the farmers (Prihandiani, Bella, Chairani, Winarto, and Fox, 2021). Again, the ATE 1, estimate was positive and significant, implying that the adoption and use of sustainable farming practices amidst climate change incidence yielded a positive increase of 990.04% in land yield and output. While, the ATE 0 was negative and not significant.

Table 5: Impacts of sustainable agricultural practices on land yield and output of farmers

PARAMETER	LATE (WALD)	LATE (IV)	ATE (IPSW)	PSM
ATE	9.1003	12.1102	22.0100	42.6401
	(15.52)***	(16.90)***	(10.01)***	
ATE 1			9.9004	
			(8.50)***	
ATE 0			-4.0880	
			(-0.75)	

Source: Field survey data, 2021. Significant at ***1%

CONCLUSION AND RECOMMENDATION

The findings of the study showed that the crop farmers were in their productive age, more of males, married, and relatively educated. A range of sustainable agricultural practices such as contour cropping, mulching, crop rotation, liming, bush fallowing, etc were adopted by the crop farmers. Age of the farmer, sex, education, farm size, extension contacts and farming experience were the major determinants of sustainable agricultural practices in the State. The adoption and use of sustainable agricultural practices increased land yield, and output in the State amidst climate change occurrences. Farmers were recommended to extensively adopt and practice sustainable farming practices to enhance yield increase, farm output and land productivity; this will boost food and crop production in the State.

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A Community-Based Approach to Climate Change Mitigation and Adaptation Through Forest Restoration: A Case Study of Anambra State

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K E Y W O R D S

Climate change,
indigenous people,
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trees,
carbon

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A B S T R A C T

Most developing countries including Nigeria are seriously affected by climate change. The role of indigenous peoples in protecting global forests and therefore regional and global climate stability has been widely recognized. The causes of deforestation in Anambra State are urbanization, land clearing for farming, bush burning for hunting, over-exploitation of medicinal plants, inadequate forest management techniques, highways and building construction. This paper suggests how indigenous communities in Anambra State can sustain their ability to use little available resources to respond to, withstand, adapt and mitigate the effects of climate change through forest restoration. There are 179 communities (Town Unions) spread throughout 21 local government districts in Anambra State. Anambra State Association of Town Unions (ASATU) where each community is represented has a women's wing that unites all the women in the State. It is intended that each community will contribute 1000 tree seedlings, for a total of 179000 tree seedlings. Each community's women shall be responsible for planting the trees in the designated locations. In the foreseeable future, the 179,000 trees planted will lower greenhouse gas emissions that worsen climate change. It would not only reduce the effects of heat waves, floods, and droughts brought on by climate change but would also have several positive economic and social effects. If 675 trees per acre would sequester around 20 tons of CO2 annually for 30 years, it implies that 179000 tree seedlings in Anambra State can sequester 5303.7 tons of CO2 in 30 years if planted

INTRODUCTION

Climate change is an adverse environmental phenomenon that is causing enormous concern all over the world. Most developing countries including Nigeria are seriously affected by climate change. This has become a major topic of discussion in modern political and economic discourse (Ikeme, 2008; Ogbuabor and Egwuchukwu, 2017; Choko *et al.*, 2019). The effects of climate change vary geographically since some areas will be more adversely affected than others (IPCC, 2007; Wood *et al.*, 2014; Mulligan *et al.*, 2016; Mishrah *et al.*, 2017). Because of disparities in sensitivity and adaptive capability between different countries and areas, climate change has a profound influence on developing countries, especially the natural resources they possess and depend on (IPCC, 2007).

In Nigeria, the effects of climate change on human health may be direct or indirect, with the most vulnerable populations being children, pregnant women, the elderly, the impoverished, and those with disabilities and chronic illnesses (Hathaway and Maibach, 2018). The severity of the hazard arising from climate change, along with the community's susceptibility to it and its capability to tolerate it, all work together to define the impact of any particular shock at the community level (Alima Ogah ,2021). The main cause of climate change is the anthropogenic increase in greenhouse gas concentrations in the earth's atmosphere. Carbon dioxide (CO_2) is the principal greenhouse gas. Its concentration in the atmosphere is the result of a cycle between different carbon pools (Karsenty, *et al*; 2003). Forests are important carbon pools which continuously exchange CO_2 with the atmosphere, due to both natural processes and human action. Planting new forests, rehabilitating degraded forests and enriching existing forests contribute to mitigating climate change as these actions increase the rate and quantity of carbon sequestration in biomass.

Nations and communities must take precautions against and reduce the effects of climate change in order to deal with that threat. Communities in forest landscapes, in particular indigenous peoples, are considered to be among the groups most vulnerable to climate variability and change as they depend on climate-sensitive activities for their sustenance and livelihoods (IPCC, 2019). The pivotal role of indigenous peoples in protecting global forests and lands, and therefore regional and global climate stability has been widely recognized (IPCC, 2019; Rainforest Foundation Norway, 2021; FAO and FILAC, 2021). It is essential to engage and partner with indigenous peoples to take climate and restoration action (Rainforest Foundation Norway, 2021). This paper suggests how indigenous communities in Anambra State can sustain their ability to use little available resources to respond to, withstand, adapt and mitigate the effects of climate change through forest and natural resources restoration.

Role of Forest Ecosystem Restoration in Climate Change Management

To alleviate the impact of climate change on the environment and livelihood sustainability in particular, strategic approach must be adopted. One of the approaches to climate change mitigation is the sustainable management of forest ecosystems (Oyewole *et al*; 2019). Forest resources have a significant role to play in achieving sustainable economic development and climate change mitigation.

Forests are a stabilizing force for the climate. They maintain ecosystem balance, are crucial to the carbon cycle, support human livelihoods, and provide goods and services that can promote sustainable economic growth. Aside from economic functions, the forest has been helpful in environmental sustainability in terms of erosion control, reduction of pollution, and provision of food and habitat for wildlife. In fact, forests are widely known as the world's largest repository of terrestrial biodiversity (Oyewole *et al*; 2019).

Stopping the loss and degradation of forest ecosystems and encouraging their restoration have the potential to account for more than one-third of the entire amount of climate change mitigation that experts estimate would be needed by 2030 to achieve the goals of the Paris Agreement (IUCN, 2021). Approximately 2.6 billion tonnes of carbon dioxide, one-third of the CO_2 released from burning fossil fuels, is absorbed by forests every year (IUCN, 2021)

In addition to providing food and timber, forests also protect biodiversity, manage water resources (due to their influence on the volume and distribution of rainfall, dynamics of water in the soil and the quantities of water discharged into the atmosphere in the form of vapour), and offer recreational opportunities (Schaphoff *et al*., 2016). According to IUCN (2021), globally, 1.6 billion people (nearly 25% of the world's population) rely on forests for their livelihoods, many of whom are the world's poorest. Hence, the need for forest restoration cannot be overemphasized.

Forest situation in Anambra State

Anambra State has the second smallest land area in Nigeria with a high human population and an alarming rate of deforestation and forest degradation because of human economic activities (Okereke *et al*; 2015). Anambra state is made up of five (5) forest zones which are also based on the five agricultural zones of the state (Ezike 2011). They include the Awka zone, Nnewi zone, Abagana zone, Otuocha zone, and Onitsha zone.

The natural vegetation in the greater part of Anambra State is tropical dry or deciduous forest, which, in its original form, comprised tall trees with thick under growth and numerous climbers (Nwosu 2003). The typical trees (silk cotton, Iroko and oil bean) are deciduous, shedding their leaves in the dry season. Only in the southern parts of the state, where the annual rain fall is higher and the dry season shorter, is the natural vegetation marginally the tropical rainforest type. Because of the high population density in the state, most of the forests have been cleared for settlement and cultivation. What exists now in many places is secondary re-growth, or a forest savannah mosaic, where the oil palm is predominant, together with selectively preserved economic trees. Relics of the original vegetation may, however, be found in some "juju" shrines or some inaccessible areas (Nwosu 2003).

The primary causes of deforestation in Anambra State are urbanization, land clearing for farming, bush burning for hunting, over-exploitation of medicinal plants, inadequate forest management techniques, highways and building construction. The land-clearing and post-clearing soil management practices in the state have an impact on the capacity of forests to store carbon. Deforestation in the state has resulted in the loss of soil nutrients, extinction of species with high economic or medicinal value, siltation of rivers, species extinction, decreased biological diversity, decreased ecosystem stability, decreased plant biomass, and disruption of the food chain, among other negative effects (Okereke *et al;* 2015). At this current rate of deforestation in the state, an untold hardship especially among the rural women who depend so much on the forest and its products is inevitable.

Community-based strategy for climate change mitigation

Forest and landscape restoration is a natural climate pathway with one of the highest mitigation potentials. Restoration through afforestation and reforestation could cost-effectively remove 0.9– 1.5 gigatonnes of carbon dioxide equivalent ($GtCO_2eq$) per year from the atmosphere between 2020 and 2050 (FAO, 2022). Forest and landscape restoration activities such as reforestation, afforestation and the integration of trees into other land use (e.g. agroforestry), can be relatively cost-effective mitigation options, especially when adapted to local socioecological contexts and considering local and distant trade-offs (Pörtner *et al*., 2021).

In order to restore the status of Anambra forest, there is need to embrace and encourage an afforestation programme which involves the establishment of a forest or stand of trees in an area where there was no previous tree cover; Reforestation programme which entails the reestablishment of forest cover, either naturally (by natural seeding, coppice, or root suckers) or artificially (by direct seeding or planting) and Agroforestry which is a sustainable land-use practice involving the deliberate combination of trees, agricultural crops and/or animals on the same land management unit. Planting of trees will improve resilience to climate variability and extreme conditions, and enhances diversity in terms of plant biodiversity and farm enterprise diversity.

Gender mainstreaming is a cross-cutting theme of scaling-up climate ambition on land use and agriculture. While women traditionally do the majority of agricultural and domestic work around the world, they are more likely to live in poverty because they lack the same access to financial and other resources, the capacity to buy land, and the authority to influence decision-making as men (Garrett, *et al*, 2022). However, in Anambra State, women are well-mainstreamed in a lot of activities which before now were not possible. For instance, some women are members of the Igwe Cabinet. In fact, in one of the towns, a woman is a Palace secretary. Hence, women shall be used to pilot the programme

The Strategy

There are 179 communities (Town Unions) spread throughout 21 local government districts in Anambra State. Each community has an Igwe and President General. The town unions have sufficient financial resources to address some issues in the localities. There is an association called Anambra State Association of Town Unions (ASATU) where each community is represented. This organization has a women's section that unites all of the women in Anambra State's communities. The tree planting will be coordinated by the women's wing.

It is intended that each community will contribute 1000 tree seedlings, for a total of 179000 tree seedlings. Each community's women are responsible for planting the trees in the designated locations, which may include their homes, communal woodlands, and along roadways as they deem fit. In the foreseeable future, the 179,000 trees planted in the state will lower greenhouse gas emissions that worsen climate change. It would not only have a significant positive influence on reducing the effects of heat waves, floods, and droughts brought on by climate change, but it would also have several positive economic and social effects.

Saving Nature (2023) states that offset estimates are based on 675 trees per acre, which sequester around 20 tons of CO_2 annually for 30 years. This means that 179000 trees in Anambra State can sequester 5303.7 tons of CO_2 in 30 years.

CONCLUSION

Environmental protection is not only the duty of the government but also of the governed. Climate change is a global problem and so all hands must be on deck to mitigate this problem. Hence community participation is crucial and would help immensely in ensuring grass root approach which would not only create awareness of forest restoration but would also create awareness in other environmental issues in the state.

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Effect of Planting Methods on the Growth and Yield of Carrot (*Daucus carota* L) in Humid Tropical Zone

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K E Y W O R D S

Carrot,
Treatment,
Direct Sowing,
Marketability,
Plant biomass

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A B S T R A C T

The experiment was conducted at the research farm of the Department of Crop Science and Horticulture, Nnamdi Azikiwe University, Awka, Nigeria; to study the effect of planting methods on the growth and yield of carrot (Daucus carota L). Two planting methods, direct sowing and transplanting were used as treatments for the experiment, which was laid out in a Randomized Complete Block Design (RCBD) and replicated four times. Data was collected on the growth, yield and root marketability. The collected parameters were statistically analyzed by analysis of variance table and means were separated using Least Significance Difference (LSD) at 5 percent level of significance with the GENSTAT 2014 Edition. The results showed no significant variation between the planting methods on the stem girth and leaf number at some dates, while transplanting significantly varied (P<0.05) from direct sowing at 4, 6, 8 and 10 WAP. Planting methods did not affect some parameters (plant biomass, root length, number of roots harvested, fresh weight of leaves, and fresh weight of roots), rather they were statistically similar. Transplanting influenced significantly the root diameter, while the harvest index showed statistical difference between the planting methods, with direct sowing varying significantly. Direct sowing also significantly influenced the root marketability parameters; root uniformity, marketable yield and total marketable root yield percetage. From the results presented, direct sowing had significant effect on root marketability, which is paramount in commercial carrot production. It is thereby recommended that for optimum carrot production and marketability, carrots should be directly sown.

INTRODUCTION

Carrot (*Daucus carota L.*), is a biennial herbaceous specie and a member of the Apiaceae family and known to be one of the most important root vegetables cultivated worldwide (Que, *et al.*, 2019). Carrots are believed to have originated in Europe or the Western Mediterranean, with origins in Persia which are now known as Iran and Afghanistan, where it was originally cultivated for its leaves and seeds (Afrin *et al.,* 2019).. In Nigeria, carrot is largely cultivated in the Northern parts like Zaria, Sokoto, Kano and Jos (Finelib.com, 2013). It has a range of colours like purple, black, red, white, yellow and orange which is the most common and popular colour.. It contains appreciable amount of carotene, thiamin, riboflavin, iron, calcium and phosphorus. Carrot is either consumed fresh (raw) or cooked (Afrin *et al.,* 2019). The root, which is the edible part, is a swollen base of the tap root that includes the hypocotyls. It is conical and its length varies from 5 to 25 cm. The high levels taste and digestibility are among the reasons why carrot is valuable (Kharsan *et al*., 2019). The flavored sweet taste of carrots referred to sugar contents such as glucose, fructose and starch which are the main types of carbohydrates (Que *et al*., 2019). Carrot therefore has been used as a potent antioxidant to combat certain types of cancer (Singh *et al.,* 2018). Carrot is used as salad, cooked as vegetables preferably with potatoes, peas and other vegetables; its juice and extracted oils are also becoming quite popular (Patel *et al.*,2019). During root enlargement, carrot is sensitive to moisture stress and water stress causes small, woody and poorly flavored roots, it also causes growth cracks (Afrin *et al.*, 2019).

Carrot is among the profitable vegetable product to promote due to its high nutritional value. However, its productivity is reduced slowly due to poor application of fertilizers, poor agronomic practices, diseases and insect attack (Ige *et al.,* 2017). Apart from temperature and nutrient composition of the soil, carrots are very sensitive to weeds and plant spacing (El-Sayed, 2021). In Nigeria the increased carrot production has become feasible by the application of sufficient plant nutrients to depleted soils to improve soil fertility (Ige *et al.,* 2017). However other factors like, wasting seeds and seedlings due to the small size of carrot seeds for the former and thinning seedlings to reduce competition for the later, water and weed management still pose a problem in carrot production. In vegetable production, nursery raised seedlings are known to be healthy, strong and have maximum germination rate. Raising vegetables in nurseries is a convenient way to plant small seeds and care for large number of seedlings in small area, while reducing seed and seedlings wastage and making production cost effective (Costa *et al.,* 2020). This study aims to determine if transplanted carrot will have positive characteristics in comparison with directly sown seeds, which can therefore reduce the cost and improve ease in carrot production.

MATERIALS AND METHODS

Experimental Site

The study was conducted at the research farm of the Department of Crop Science and Horticulture, Nnamdi Azikiwe University, Awka. This area has a mean rainfall range above 1100mm and lies between latitude 06º15N, longitude 07º08E, with a minimum and maximum average temperature of 27ºC to 30ºC (Ndukwe *et al*., 2020).

Experimental Materials and Treatment Application

The carrot Seeds used in the experiment was the Carrote Touchon variety which was obtained from a reputable seed dealer in Jos, Plateau State. Two treatments which were replicated 4 times were applied: T1 - transplanted carrot T2 - directly sown carrot.

Field Experiment Description

The experiment was laid out in a complete Randomized Complete Block Design (RCBD) replicated four times and conducted in a field with a total area of 17m x 23m. The field layout was designed using randomization to allocate each treatment and their replications to specific plots (beds) without bias. The chosen site of 17m x 23m was cleared of its existing vegetation, manually with cutlass, before beds of 1m by 2m and furrow spacing of 0.5m were raised with hoes. The beds were then incorporated with poultry manure at equal rates to aid the growth of the carrot. Part of the chosen site was also tilled and incorporated with poultry manure as the nursery.

Sowing of Seeds

For treatment 1, directly sown treatment, the carrot seeds were sown at the rate of 4 per hole at 2cm depth and with the plant spacing of 30cm by 50cm. While the seeds for the transplanting was evenly broadcasted in the nursery. The carrot seedlings in the nursery were transplanted three weeks after germination into raised beds of 1m by 2m, the seedlings were spaced 30cm × 50cm. The directly sown seedlings were thinned down to one seedling per stand.

Data Collection and Analysis

Data for the growth parameters (plant height (cm), number of leaves per plant, stem girth per plant (cm),were collected at the interval of two weeks after planting. While the yield parameters(diameter of root per plant (cm), total yield of roots per bed (tones/ha), plant biomass (g), harvest index on fresh weight basis (%), number of harvested root per bed, root length (cm), root marketability (those ones that were smooth, sizable and neat at sight without deformity), marketable yield (tones /ha),total marketable root yield (%), root uniformity (%))were collected immediately after harvest. The collected parameters were statistically analyzed by analysis of variance table and means were separated using Least Significance Difference (LSD) at 5 percent level of significance with the GENSTAT 2014 Edition.

Tuber uniformity (%)

Data was collected on root uniformity by visual examination of the roots using a uniformity index score created as shown Table 1.

Table 1.Root uniformityindex score

Index		Description
1	Not Uniform	<30% of the roots are similar in size and shape
2	Fairly Uniform	>30%<50% of the roots are similar in size and shape
3	Uniform	>50%< 70% of the roots are similar in size and shape
4	Very Uniform	>70%<90% of the roots are similar in size and shape
5	Highly Uniform	>90% of the roots are similar in size and shape

Source: Obidiebube *et al.,* (2022)

RESULTS

Physico chemical properties of the soil samples utilized in the study

The result of analysis carried out with soil samples collected from the experimental site as presented in Table 2., shows the physical and chemical soil properties. Based on the physical soil properties, there was high percentage of sand (71.2%), clay was the least (8.4 %) while the textural class of the soil is sandy-loam. The chemical soil properties showed the percentage base saturation to be 80.23 %, organic matter 1.98%, and Total N0.97%, other parameters were also determined.

Table 2: Physical and Chemical properties of the soil samples taken at 0 – 15cm depth of the experimental site before planting.

Soil Properties	Value
Physical	
Sand (%)	69.6
Silt (%)	22.0
Clay (%)	8.4
Textural Class	Sandy-Loam (SL)
Chemical	
pH (H20)	5.14
Total N%	0.97
Organic Carbon%	1.14
Organic Matter%	1.98
Ca (Cmolkg-1)	2.27
Mg (Cmolkg-1)	1.33
K (Cmolkg-1)	0.25
Na (Cmolkg-1)	0.12
EA (Cmolkg-1)	1.63
ECEC (Cmolkg-1)	4.97
BS (%)	80.23
Available P (mgkg-1)	5 53

Source: Department of Soil Science and Land Resources Management Soil Laboratory, NAU, Awka

Effect of Planting Methods on the Vegetative Growth (Plant Height, Number of Leaf and Stem Girth) of Carrot (Cm):

In Table 3, it was observed that plant height of the transplants progressively increased across the sampling periods; and were mostly higher than the directly sown seedlings. At 4 and 12 WAP Treatment 1 (transplants) had the highest mean values of 19.8 and 59.2 respectively, while Treatment 2 (directly sown) had the mean value of 15.21 and 43.8 at 4 and 12 WAP respectively. With this result in Table2 I 4 and 12 WAP, transplants were significantly different ($P<0.05$) from directly sown plants. In the same Table 2, both methods were significantly similar ($P<0.05$) at 6, 8 and 10 WAP (Weeks After Planting).

On leaf number, Table 3 showed that the planting methods had no significant effect ($P<0.05$) on the leaf number of the carrots. The highest mean values were observed from 12 WAP with transplants having mean value of 23.2, while directly sown plants had 18.8 and was not significantly different ($P<0.05$).

Finally, with the highest mean values of the stem girth as 15.31cm (T1) and 12.10cm (T2) at 12 WAP and least mean value of 3.42cm (T2) at 4WAP, planting methods did not significantly ($P<0.05$) influence the size of the stem girth throughout the sampling periods as indicated in Table 3.

Table 3: Effect of planting methods on the plant height, number of leaves and stem girth of carrot.

		Plant Height			
Treatment	4WAP	6WAP	8WAP	10WAP	12WAP
1	19.84	35.1	49.4	51.9	59.2
2	15.21	28.2	38.8	48.0	43.8
LSD 5%	3.614*	5.18 ns	5.93 ns	6.03 ns	5.31*
		Leaf Number			
T1	4.17	6.33	10.75	16.4	23.2
T2	3.42	6.08	10.50	14.1	18.8
LSD 5%	1.448 ns	1.614 ns	3.503 ns	5.49 ns	11.28 ns
		Stem Girth			
T1	1.91	4.33	8.51	13.23	15.31
T2	2.13	4.02	7.48	11.43	12.10
LSD 5%	0.75 ns	1.33 ns	2.721 ns	3.77 ns	4.26 ns

T1 - Transplanted Carrot, T2 - Directly Sown Carrot

Response of some carrot yield parameters to planting methods

On biomass shown in Table 4, no significant difference (P<0.05) was observed between the plant biomass of the transplanted and directly sown carrot.

For fresh weight of leaves in Table 4, it indicates that the planting methods had no statistical influence on the fresh leaf weight of the transplanted and directly sown carrots, showing that the transplants and the directly sown plants were significantly similar (P<0.05). The highest mean value was produced by T1 (330) followed by T2 (213).

On fresh weight of roots as was recorded Table 3, the fresh weight of the harvested roots did not significantly vary (P<0.05) and were not influenced by the effect of the planting methods, Transplanting and Direct Sowing. The highest average root weight recorded was that of T (145) and the lowest was T2 (120).

Finally, on harvest index% planting methods influenced the harvest index of carrot. As portrayed in Table 3, the harvest index of the transplanted and directly sown carrot differed significantly (P<0.05), with the directly sown plants statistically influenced the harvest index. The highest index recorded was obtained from T2 (56.8%) and lowest T1 (43.3%).

Table 4. Effect of planting methods on plant biomass, fresh weight of roots, fresh weight of leaves and harvest index% of carrot.

Treatment	**Plant Biomass**	**Fresh Weight of Roots ns**	**Fresh Weight of Leaves ns**	**Harvest Index %**
T1	330	145	186	43.3
T2	213	120	95	56.8*
LSD 5%	153.9	70.7	105.2	10.25

Response of number of roots, rootlength and diameter per plot to the planting methods

Statistically there was no significant difference (P<0.05) between the number of roots harvested per plot of the transplanted and directly sown carrot, indicating that the planting methods applied as treatments did not influence the number of carrot root produced as revealed by Table 4. The highest producing plot/bed during the course of this study was T1 (6.25), whilst T2, produced 5. 75 roots which was the lower than that of T1.

Result in Table 5 showed that root length of the transplanted and directly sown carrots did not show any significant (P<0.05) variance. Hence planting methods did not have significant effect on the length of roots produced. The lowest root length mean observed was that of T1 (17.2 cm) while TR2 (20.4 cm) gave the highest mean value.

On root diameter recorded in Table 5, it showed that planting methods influenced the root diameter of the transplanted and directly sown carrots. The transplants were significantly different (P<0.05) from the directly sown carrots and affected the diameter of the roots produced. The T1 had 5.58 while T2 had mean value of 3.93.

Table 5. Effect of planting methods on number of roots harvested per plot, root length and root diameter of carrot

Treatment	No HR/plot ns	Root Length	Root Diameter
T1	6.25	17.2	5.58*
T2	5.75	20.4	3.93
LSD 5%	3.837	9.41ins	0.842

Results on the Marketability of Carrot Roots

Effect of planting methods on the root uniformity, marketable yield and percentage

The roots of the harvested carrots as illustrated in Table 6, varied significantly (P<0.05) with the directly sown carrots having higher uniformity than the transplanted carrots showing that planting methods had significant influence on the shape and size of the harvested carrots. The directly sown plants resulted in highly uniform roots per plot with the highest value being 4.25 while transplants had 2.00.

On marketable yield, result in Table 6 showed that planting methods influenced the root marketable yield, with the directly sown carrots varying significantly (P<0.05) with higher values than that of the transplants. The directly sown plants had highest marketable value 5.75 out of 7 harvested, while transplants had 2.5 out of 7 too.

Finally, on yield % in Table 6, resultportrayed a significant difference (P<0.05) between the transplanted and directly sown carrots. Planting methods therefore influenced statically the marketability% of carrots. The marketability Yield% of the directly sown plants was significantly (P<0.05) higher than that of the transplants.

Table 6. Effect of planting methods on the root uniformity, marketable yield and marketable yield% of carrots

Treatment	Root Uniformity	Marketable Yield	Marketable Yield%
T1	2.00	2.5	26.0
T2	4.25*	5.75*	100.00*
LSD 5%	1.539	1.966	23.86

DISCUSSION

The results of the growth parameters on transplanted and directly sown carrots observed in this experiment followed a significantly similar trend in almost all the growth prameters across the weeks after planting WAP. This is in line with Leskovar and Othman, (2021) who reported on globe artichoke, that direct seeding and transplanting were statistically similar in both periods of experimenting. The findings here also agrees with the work of Adesina *et al* (2014), who observed similar heights between the direct seeded and other seedlings transplanted at 19 and 14 DAP in maize, as regards plant height.

Meanwhile, the statistical significance between the plant height of the planting methods at 4 and 12 WAP can be attributed to climatic conditions and more importantly a reduction in the mean values of the directly sown plants after 10 WAP as opposed to the continuous improvement in the plant height of the transplants. This finding agrees with Afrin *et al*., (2019), work on directly sown carrots, which indicated that, plant height was an important growth contributing character during the experiment, in which the growth rate of the plants at earlier stage were higher, then became slower at the later stage of development, as noticed with the directly sown carrots. The transplanted, did not follow this trend, instead it grew progressively which resulted in the significant difference observed. This resonates with Leskovar and Othman's (2021) report that more uniform growth is higher in transplants compared to direct seeding. The root diameter was significantly influenced by planting methods, with the transplanted seedlings having higher value when compared to the directly sown seeds, which is in agreement with the reports of Khozaei *et al* (2020), when commented that transplanting significantly influenced the yield, water productivity and quality of sugar beet. The significant similarity between planting methods in the root length corresponds to the findings of Mbatha *et al* (2014), who observed that carrot root length was not significantly influenced by any of the treatments applied. It also concedes with Leskovar and Othman's (2021) report that length values for direct seeded plants never exceeded those of transplants across months and over the study period in globe artichoke. The observed non significance difference on the fresh root weight (FTW) and number of harvested roots per plot (NHP) are in tune with Nikmatullah *et al* (2021) and El-Sayed (2021) who respectively stated that there was no significant difference observed from the planting methods applied on carrot and that, there were no differences between the two planting methods concerning the yield and root weight of carrot. On number of harvested plant, Adesina *et al* (2014) reported that fruit yield in maize was not significantly influenced by planting methods (transplanting and direct seeding), instead it was influenced by planting density.

The Harvest Index resulted in significant variance between transplants and the directly sown plants where directly sown plants had significant higher values. This corresponds with Kakar *et al*., (2015) report which revealed that planting methods had significantly affected the harvest index of wheat. The Marketability Parameters followed the same trend; root uniformity, marketable yield and marketable yield percent (%) all differed significantly, with the direct sown carrots significantly influencing all marketable parameters. According to Leskovar and Othman (2021), planting methods affect marketable yields, root and shoot biomass allometric partitioning and early root development amongst others. This is similar to carrots, as the planting methods (transplanting and direct sowing) influenced the marketable quality of the roots. Significant difference between planting methods in root uniformity can be attributed to the dissimilarity in size and shape of the harvested carrot roots. The forked, irregular and ill-shapen roots harvested from the transplants which is as a result of transplanting, greatly reduced uniformity. This is because most roots harvested from the transplants were of irregular shapes and sizes when compared to the direct seeded roots. According to Fritz, (2012) transplanting of long-rooted vegetables leads to forked roots. This finding is consonant with the study of Wu *et al* (2020), who reported that direct seeding in carrot production is more suitable and transplanting would lead to the occurrence of fork root and loss of commercial value. It was observed that later most nursery raised seedlings resulted in forked roots. Costa *et al* (2020) on another crop reported that direct sowing presented the highest numbers of total and commercial ears per hectare and that transplanting in general, caused loss of commercial fruit quality in baby corn production. Direct sowing significantly increased the Harvest Index and root marketability, which is very important in Carrot production.

CONCLUSION AND RECOMMENDATION

In consideration of the aforementioned results, planting methods did not significantly influence the growth and yield of carrot in the course of this study. Instead direct sowing had significant effect on root marketability which consists of root uniformity, marketable yield and marketable yield%.

Finally, though planting methods used here did not influence both growth and some yield parameters, but then directly sown method carrots is better because the roots are normal in size and shape, therefore should be used for carrot production, until further experiments on other planting methods are completed. It is therefore recommended that carrot seeds should be sown directly for optimum carrot production

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Characterization and Consumption of Edible Insects among Households in Oji River Local Government Area, Enugu State, Nigeria

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A B S T R A C T

This research was on characterization and consumption of edible insects among households in Oji River local government area of Enugu State, Nigeria. Purposive sampling technique was used to select one hundred and twenty (120) respondents used for the study. Data were collected with structured questionnaire and interview schedule. Data were analyzed using descriptive statistics while the hypothesis was tested using simple regression analysis at 5% level of significance. The results revealed that males especially middle aged were more involved in the consumption of edible insects. Large family size of the respondents could be their reason for consuming edible insects to supplement their protein intake. Majority of respondents have basic education hence are well informed of the nutritional value of insects. Majority of the respondents were civil servants and spent between ₦10,000 - ₦20,000 per month on consumption of edible insects. Majority (100%) of the respondents enjoyed eating winged termite, cricket, larva of a species of butterfly (Wiwi or Nwigu) and honey from bee. The hypothesis showed that socio-economic characteristics did not significantly affect the level of consumption of the insects. It was recommended that farming/rearing and harvesting of edible insects should be part of the farming systems in the study area and that more awareness campaigns created.

INTRODUCTION

Entomophagy is the human consumption of insects as food (Adeoyo Job, Abiodun and Dare, 2014). It is indigenous to Nigeria and most other African nations. The consumption of edible insects seems to be on a steady increase in recent time especially in the study area despite the fact that real insect farming is seemingly unpopular in most part of the country (Ezeano, 2020). According to Van Huis (2016) insects are among the most diverse groups of animals on the planet. There are more than 1 million described species, which is more than half of all known living organisms.Insects are class of animals within the arthropod group that have a chitinous exoskeleton, a three-part body (head, thorax and abdomen), three pairs of jointed legs, compound eyes and two antennae. The utilization and consumption of edible insects is continuously growing as people are increasingly interested in the new resource. According to Ebenebe and Okpoko (2017) traditional dishes are prepared with edible insects but in all of these dishes, edible insect inclusion is optional.

In Achi, Oji River local government area of Enugu State, edible insects are delicacies meant for the bourgeoisie, youths and titled men. It is included in traditional dishes like Tapioca (Abacha) and traditional soups during festivals like traditional marriages, funeral ceremonies, coronations, *ofala* and traditional feasts. Fried locusts and other edible insects are imported into Achi from Maiduguri and other northern states for their ceremonies.

The protein content of insects depends on the metamorphosis stage; adults usually have higher protein content than instars source proteins. Blasquez, Moreno and Camacho (2012) edible insects are richer in proteins (60%) compared to beans (23.5%), Lentils (23.5%) and Soybean (41.1%). It is only fish (81%) that surpasses edible insects in protein content.

According to Ezeano (2020) with decline in bush meats as a food source in Nigeria due to deforestation and diseases associated with wild life consumption, edible insects could play a more important role in food security The supply of most edible insects is scarce and occurs mainly during the rainy season (Ebenebe, Amobi, Udegbala and Ufele, 2017). In spite of the seemingly nutritional, economic, environment and health benefits of edible insect, empirical research evidence documenting edible insect farming and consumption pattern in Nigeria remains relatively few (Ebenebe *et al.* 2017) and (Meludu and Onoja, 2018).

The problem is that there is a serious shortage of animal protein in the diet of most Nigerians and edible insect consumption can be an alternative source which this research is intended to fill.

According to Ebenebe and Okpoko (2015) the shortage of animal protein in the diet of Nigerians and other developing countries necessitates a search for alternative animal protein source to augment the conventional meat proteins in meeting the animal protein needs of the populace. Thus this research is an attempt to bridge the gap between animal nutrient deficit and human population growth rate as well as managing the health risk associated with meat consumption. Therefore, insect consumption as an alternative source of nutrients has been recommended to form integral aspect of the nation's traditional farming system and consumption.

Objectives

The main objective of this study was the characterization and the consumption of edible insects among households in Oji River local government area of Enugu State. Nigeria. Specially, the study described the socio-economic characteristics of the respondents, identified and characterized the major edible insects predominant in the area, determined the level of consumption of edible insects in the study area.

Research Hypothesis

The hypothesis stated that Socio-economic characteristics do not significantly affect the level of consumption of the insects in the study Area and was tested at 0.05 level of significance

This study has provided the populace with information on the characteristics of edible insects and it serves as a resource material to other researchers who might be interested in studying edible insects in their respective locations.

METHODOLOGY

Research Design

A survey research design was adopted for the study which sampled individual units of a population and questionnaire was used to elicit data from the respondents in the study area.

Area of the Study

This research was carried out in Oji River Local Government Areas of Enugu State, Nigeria. Oji River is located at Latitude 06˚16N and Longitude 07˚16E with Altitude of 140m above sea level. The mean annual rainfall is 2000mm, while the annual temperature ranged between 26.8˚C and 32.5˚C; the average Relative Humidity is 84%. Oji-River is bounded to the south by Anambra state. The people of the study area are mainly farmers and the area is well suited for natural breeding of edible insects. The major towns in Oji-River are: Achi Agu, Achi Uno, Inyi, Awlaw, Akpugoeze and Ugwuoba.

Population of the study

All the households involved in harvesting, and consumption of edible insects formed population for the study and is therefore infinite.

Sampling Procedure and Sample Size

Stage 1: Oji-River local government area was purposively selected for this study because it is naturally endowed with the ecology, soil type and vegetation that support the natural breeding and rearing of these edible insects.

Stage 2: Four (4) towns where these edible insects breed naturally were purposively selected; Achi-Uno, Achi-Agu, Awlaw and Inyi;

Stage 3: One hundred and twenty (120) respondents that are popularly involved in harvesting, and consumption of these edible insects were purposively selected in this order Achi-Agu (30) ,Achi-Uno (30) ,Awlaw (30), and Inyi (30) giving a total sample size of 120 respondents.

The instruments used for data collection were structured questionnaire for literate respondents and interview schedule for illiterate respondents The instruments were validated by a Statistician and an Extensionist from Enugu State University of Science and

Technology. Their corrections were used to produce the final draft. Responses with numerical values were subjected to reliability test using Kuder Richardson (KR21) which gave a value of 0.86 (86%) ,indicating high level of reliability.

Method of Data collection

The researcher trained two Research Assistants that helped in data collection. The structured questionnaire was given to literate respondents who filled them on the spot while the interview schedule was used by the Researchers to elicit information from the illiterate respondents by asking them questions and filling in the responses into the questionnaire.

Data Analysis

Data collected from the respondents were analyzed using percentage, frequency and mean scores.

Objectives 1,2,3 and 4 were achieved by use of mean, percentage and frequency counts, while hypothesis 1 was tested by use of simple regression analysis at 5% level of significance. The null hypothesis was accepted if the p- value is greater than 0.05 and rejected if otherwise

RESULTS AND DISCUSION

Socio-economic characteristics of respondents.

Table 1 shows the socio- economic characteristics of the edible insect consumers in the study area.

Table 1: Socio-economic characteristics of the respondents

	Frequency	Percentages	Mean	Standard deviation
Sex				
Male	64	53.33		
Female	56	46.67		
Age				
Less than 15	3	2.50	34.3	0.1
15-25	50	41.67		
26-40	24	20.00		
41-60	35	29.17		
Above 60	8	6.67		
Marital Status				
Single	71	59.17		
Married	45	37.50		
Divorced	0	0.00		
Widow	4	3.33		
Household size				
1 – 4	43	35.83	5.7	0.2
5-8	56	46.67		
9-12	21	17.50		
Above 12	0	0.00		
Educational Attainment				
No formal education	8	6.67		
Primary education	11	9.17		
Secondary education	56	46.67		
NCE/B.Sc.	40	33.33		
M.Sc. and above	5	4.17		
	120	100.00		
Income spent on edible insect Less than ₦10,000/month	43	35.83		₦14047.387
₦10,000-₦20,000/month	43	35.83		
₦21,000- ₦30,000/month	13	10.83		
₦31,000-₦40,000/month	16	13.33		

₦41,000-₦50,000/month	5	4.17		
Occupation				
Full-time farmer	21	17.50		
Civil/ public servant	64	53.33		
Part-time farmer	21	17.50		
Edible insect harvester	14	11.67		
Membership of social organization				
1 -2	72	60.00	2.8	0.01
3-4	24	20.00		
5-6	13	10.83		
above 6	11	9.17		
Total	**120**	**100.0**		

Sex: Table 1 shows that the males constitute the majority (53.33%) while the female (46.67%) constitute the minority. The implication of this finding is that males are more involved in the consumption of edible insects in the study area.

Age: Table 1 shows that the majority (41.67%) of the respondents are between the ages of 15-25, 20.00% of them are between the ages of 26 to 40, This implies that youths constitute the majority of the people that consume insects in the study area followed by middle aged people. This finding agrees with apriori expectation that youths in the study area enjoy eating edible insects

Marital Status of the Respondents: Table 1 shows that the majority (59.17%) of the respondents are single, 37.50% of them are married. This confirms the apriori expectation that youths constitute the majority of the insect consumers. This is probably because they have enough energy required in the harvesting of these insects.

Household size of the Respondents: Table 1 shows that the majority (46.67%) of the respondents have between 5 – 8 members in their family, The respondents have large family size with mean of 6 which is common in the study area. Probably they consume a lot of insects to complement or supplement their feeding.

Educational Background of the Respondents: Table 1 shows that majority (46.67%) of the respondents attained secondary education level,while, 33.33% have acquired their NCE/B.Sc. certificates,. The implication is that the respondents are well informed and knows the nutritional value in the consumption of insects.

Monthly Income of Respondents spent on Edible Insects consumption: Table 1 shows that majority (35.83%) of the respondents spent between ₦10,000-₦20,000 every month, on consumption of edible insects. This is really a lucrative business in the study area and no wonder youths are mainly involved in the enterprise.

Occupation of the Respondents: Table 1 shows that the majority (53.33%) of the respondents are civil/public servants, while 11.67% of the respondents harvest edible insects. The implication is that the respondents probably used the enterprise to augment their poor salaries.

Number of Social Organization the Respondents belonged to: Table 1 shows that the majority (60.00%) of the respondents are members of 1 to 2 social organizations, 20.0% of the respondents belonged to 3 to 4 organizations. The implication is that the respondents are well exposed and have high interaction which informed the knowledge of the nutritional value of the insect.

Table 2 shows that majority (100%) of the respondents correctly characterized the following insects cricket, winged termite, soldier termite *,omuru ,ikpuru*, grasshopper, *egu* and *wiwi* or *nwigu* describing their features and habitats.This agreed with insect characterization of Ezeano, (2020)

Table:2 Characterization of some edible insects.

Insects	Features	Habitat	%
Black aphids (Okpo)	Has two thorns on the head	lives in Agidi local cowpea, Ichakiri	80.5
Praying mantis(Nkori)	has slimmy cylindrical body with long antennae	Green schrubs	60.5
Cricket (Abuzu)	Adults has wings while the nymph has small wings	grass land areas mostly seen around April, May, June and July), burrows and lives inside the soil, the adult male and female fly in the night during mating season and are called Ebio	100.0
Winged termite (Aku)	Has slimmy white wing	Seen normally in the night under light around May/June). Lives in the termitarium or termitary (Mkpu)	100.0
Soldier termite (Akika)	with red big head	Termitary	100.0
Queen termite (white larva),	Rounded fatty white body	Lives in the termitarium or termitary (Mkpu)	100.0
Buru ishikwuo ukwo (leafy crops Akidi)	has no head but cylindrical structure	Found in local cowpea (Akidi)	50.5
Okochi (Agbada)	has protruding eyes	mainly found in Agba tree during dry season.and dry banana leaves	60.0
Shi-shishi brown Shi-shishi green		Dry banana leaves Green banana leaves	45.0
Omuru; beetle found around January to march	with shiny green body	Oka, Okpokoro, ububo,utompuma,cashew	100.0
Ikpuru; beetle found around January to march	with brown body	Oka, Okpokoro, ububo,utompuma,cashew	100.0
Zenocerous variagatis(Otuwom); green grasshopper (bitter leaf, cassava), Grasshopper; brown (Elephant grass), Gbaratu,(Brown), Ji-ji-ji, Locust; (Igurube),	Thorney hind leg with double wings	Bitterleaf, Cassava leaf, Elephant grass, All grasses	100.0
Okpanka;	Has smooth body	Okpokoro ,oka ububo,utompuma	50.0
Ogwogorogwo	with thorns	Oka,ububo utumpuma ,cashew, akpaka	60.0
Upanata	with hairy body	Alulu, Okpokoro oka, ububo,utompuma	70.5
Egu–	Red and Black with thorns	Umbrella tree, Ukpaka, Oka, Ukwa	100.0
Wiwi or Nwigu;	bluish black	Ukwa, Akpaka, Oka ububo,utompuma	100.0
Ikpuruala	Larva with big jaw	lives inside the soil under oka,ububo,utompuma okpokoro	60.5
Mgbaba	with hairy body	,found in Oka, ububo,cashew, utompuma	50.0
Rhinozerus beetle	black with thug like elephant	found in oil palm tree	50.0
Raffia palm larva; pupa with small wing, Raffia palm caterpillar; larva,	Whitish body	Found in raffia palms	55.0

Raffia palm beetle	Has thick wing	found in raffia palm trees.	60.0
Onumanya, oil palm- greenish	Has thick wing	found sucking fresh palm wine	60.5
Kpukpakpa	with big head and claws	found in grassland areas	50.0
Mgbangba	black ant with fatty big belly	seen during the onset of rain (lives inside the soil and flies like winged termite)	65.0
Mbe	winged termite	end of rainy season around October lives inside the soil	80.0
Mkpoma	winged termite	onset of rainy season March /April lives inside soil	
Nwamiri			85.0
		lives inside the soil found around june/july	
	winged termite		75.0
Giant black scorpion	Has jointed black body with tail.	found in grass land area	30.0
Okukoro with rough wing	Green with long legs	seen on green hedges Ukpodu, Aboshi	60.0
Ohuha with smooth wing	Has smooth slimmy body	green hedges	65.5
Aboke- greenish	Has greenish body	found in all schrubs	50,0
Ami or Apia	slimmy with pointed body	found in grass land areas.	75.0
Yam beetle (Ebe)	Has dark hard wing	lives inside the soil in yam farms	60.0
Date Palm larva	Has whitish soft fatty body	lives in date palms	35.5

Table 3 revealed that the following insects are consumed at high level; Cricket ($\bar{X}$ = 3.09), Wiwi ($\bar{X}$ = 3.46), Omuru and Ikpuru (beetle) ($\bar{X}$ = 3.27), Winged termite ($\bar{X}$ = 3.96). Grasshopper ($\bar{X}$=3.42),and honey from bee ($\bar{X}$=3.72).The rest have low level of consumption. This indicates that the insects highly consumed are the ones readily available and accessible in the area. This observation is in agreement with the report by Van Huis *et al*. (2013) that most commonly consumed edible insects are beetles, grasshoppers, locusts and crickets, cicadas, leafhoppers, plant hoppers, scale insects and true bugs, termites, dragonflies.

Table 3: The respondents' level of consumption of some edible insects

Insects	VHL	HL	MH	LL	VLL	Mean	Remark
Cricket	24	24	35	13	24	3.09	**
Wiwi	48	13	21	22	16	3.46	**
Omuru$ Ikpuru	37	22	24	10	27	3.27	**
Winged termite	49	34	22	13	2	3.96	**
Grasshopper	10	22	16	32	40	3.42	**
Caterpillars	5	8	35	27	45	2.18	*
Locust	5	30	35	27	23	2.73	*
Honey Bee	23	20	32	30	35	3.72	**
Praying mantis	19	11	10	32	48	2.34	*
Date palm larva	0	3	19	11	87	1.48	*

** High consumption *low consumption

Test of hypothesis

From Table 4, the following regression equation was generated**.** Level of consumption (Y) = 7.576 - 1.019X1 - 0.283X2 + 0.148X3 - 0.665X4- 0.457X5 +0.120X6 -0.589X7 + 0.518X8+ µ .Where, Y =level of consumption of the insects, X_1 =Sex, X_2 =Age of respondent (years), X_3 = Marital status of respondent, X_4 = Household size(number), X_5 = Educational Attainment, X_6 = Income from sale of edible insect(₦), X_7 = Occupation of respondent, X_8 = Membership of social organization, µ =Error term.The coefficients result in table 7 indicates significant positive correlation linking membership of social organization to level of consumption of insects. The table indicates that there is a significant negative correlation linking sex, age, household size, educational attainment and occupation to level of consumption of insects. Finally, the table indicates that there is a positive non-significant correlating marital status and income spent on edible insect consumption in the area. This finding is in agreement with Ezeano (2020) that consumption of edible insects in Oji River is widespread and is not based on status.

Table 4: Level of consumption of the insects and socio-economic characteristics of respondents in the study area.

Coefficients[a]					
Model	Unstandardized Coefficients		Standardized Coefficients	T	Sig.
	B	Std. Error	Beta		
(Constant)	7.576	.173		43.684	.000
Sex	-1.019	.145	-.356	-7.019	.000
Age	-.283	.107	-.205	-2.654	.009
Marital status	.148	.130	.070	1.144	.255
Household size	-.665	.181	-.329	-3.668	.000
Educational Attainment	-.457	.096	-.290	-4.772	.000
Income spent on consumption of edible insect	.120	.161	.098	.749	.455
Occupation	-.589	.127	-.361	-4.626	.000
Membership of social organization	.518	.105	.359	4.922	.000

Summary

This research analyzed the characteristics and the consumption of edible insects among households in Oji River local government area of Enugu State. The study revealed that middle aged males are more involved in the consumption of edible insects in the study area. Majority of respondents have basic education hence are well informed of the nutritional value in the consumption of insects. The majority of the respondents are civil servants who spent ₦10,000 - ₦20,000 per month on consumption of edible insects. Majority of the respondents enjoy eating termite, cricket, wiwi, Omuru/Ikpuru (beetle), grasshopper, and honeybee. The result of the hypothesis showed that socio-economic characteristics do not significantly affect the level of consumption of insects in the study area. This implies that the level of edible insect consumption is not dependent on the socio-economic characteristics hence anybody can consume it because it is affordable when compared with other sources of animal protein.

CONCLUSION AND RECOMMENDATIONS

This study revealed that males are more involved in the consumption of edible insects in the study area and that middle aged constitute majority of the consumers

Based on the findings of this study, the following recommendations were made:

Mass rearing of edible insects would be the most appropriate solution for its availability all year round hence more studies should be conducted on the development of techniques for mass rearing of edible insect species and more campaigns on nutritive value

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Effects of Neem, Gmelina, and African Velvet Tamarind Wood Fuel on the Organoleptic and Shelf Life of *Clarias gariepinus*

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K E Y W O R D S

Clarias gariepinus
Organoleptic,
Shelf life,
Smoking,
Wood fuel,

*C O R R E S P O N D I N G A U T H O R

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A B S T R A C T

This work aimed to evaluate the effects of smoking African catfish (Clarias gariepinus) using wood fuel obtained from Neem (Azadirachta indica), Gmelina (Gmelina arborea) and African velvet tamarind (Dialium guineense) on the organoleptic properties (appearance, aroma, taste, and texture) and shelf life. The research was conducted at the fish processing unit of the Department of Fisheries and Aquaculture Management, Nnamdi Azikiwe University, Awka. A total of 12 matured catfish, 6 males and 6 females which weighed 1kg each were used for the study. After fish preparation, a total of four fish (2 males and 2 females) were smoked in three different smoking kilns using the three wood types. The organoleptic properties of the smoked catfish were analyzed by ten member panel while shelf life was determined by the period of mold and insect infestation. The results indicated that there was no significant difference ($P>0.05$) in the effects of these wood types on the organoleptic properties assessed. However, catfish smoked with the African velvet tamarind wood had the most preferable organoleptic qualities with a mean score of appearance (4.20 ± 0.92^{a}), aroma (4.30 ± 0.82^{a}), taste (4.70 ± 0.67^{a}), and texture (4.10 ± 0.86^{a}). This was followed by catfish smoked with Gmelina wood with a mean score of appearance (2.90 ±0.88a), aroma (3.00 ± 0.94^{a}) taste (3.00 ± 0.67^{a}), and texture (2.90 ± 1.19^{a}), while catfish smoked with Neem wood had the lowest mean score of appearance (2.00 ± 0.67^{a}) and texture (2.50 ± 0.85^{a}). It was also observed that there was no insect attack in all the smoked fish samples during the period of storage. However, catfish smoked with Neem wood showed the highest severity to mold attack (3.00) while fish smoked with Gmelina wood showed no mold attack (0.00). Therefore, these results indicated that fish processing with the use of these woods is effective in extending the shelf-life of smoked African catfish. As a result, the study suggests that the use of African velvet tamarind wood in smoking fish should be adopted to improve the organoleptic properties of smoked catfish which would also increase its profitability.

INTRODUCTION

Fish has traditionally been an important food source for humans and contains high-quality protein, vitamins, and omega-3 fatty acids. Fish is the most perishable of all food commodities, as it deteriorates after death (Kwaghvihi *et al.,* 2020). Inadequate post-harvest preservation and processing of fish can cause massive spoilage (Kumolu-Johnson *et al*., 2010). Smoking has been used as a preservation technique for centuries to preserve fish (Rahman, 2007, Huong, 2014) and extend their shelf life.

Smoking is the process of flavoring, cooking, or preserving food by exposing it to smoke from burning or smoldering materials, most commonly wood. In recent times, smoking is used as a method of preservation with the incorporation of smoke flavor and the development of color (Varlet *et al*., 2007). Smoking introduces aroma, taste, and color to processed fish (Visciano *et al*., 2008). Smoking also retards the development of toxins in fish products (Huong, 2014) and extends their shelf life due to the dehydrating, antimicrobial and antioxidant effects of smoke components (Visciano *et al*., 2008). It reduces the growth of bacteria, through the removal of moisture in fish induced by heat application and drying which creates a physical surface barrier (Rorvik, 2000). The spoilage and pathogenic microflora of smoked products are affected by the density of smoke, the concentration of active components of the smoke in combination with the salt content, and, the time and temperature of smoking (Kwaghvihi *et al.,* 2020).

The chemical composition of smoke is complex and more than 300 components have been identified (Guillen and Manzanos, 1999). Smoke is generated through the incomplete combustion of wood (Muyela *et al*., 2012) and contains phenolic compounds, acids, and carbonyls which contribute significantly to the overall flavor of smoked fish. The relative concentration of phenolic compounds depends on the nature of the wood used in the smoking process (Serot *et al*., 2004). These active compounds are effective in improving the shelf life as well as the organoleptic properties of the fish.

Fuel wood is the main source of energy for smoking fish, though many wood types can be used as fuel for smoking fish. Fuel wood used as a smoked source in fish smoking can be hardwood such as beech, neem, gmelina, oak, or fruitwood such as apple, tamarind velvet, etc (Huong, 2014). Plant-based natural constituents can be derived from any part of the plant like bark, leaves, flowers, roots, fruits, seeds, etc, and may contain active components (Ajiboye *et al.,* 2015). Medicinal plants have been used for centuries as remedies for human diseases and offer a new source of biologically active chemical compounds as antimicrobial agents. Among all the factors influencing the choice of wood, the type of wood used is dependent on local availability (Nerquaye-Tetteh *et al*., 2002). The fuel wood preferences of most fish smokers are related to the physical characteristics of the wood and how they affect the smoked fish. Different fuel woods may affect the quality of the smoked fish differently (Nerquaye-Tetteh *et al*., 2002).

The organoleptic properties and shelf life of smoked fish depend on the type of wood used in smoking. The chemical composition of wood differs from one another, which can influence greatly these properties. These organoleptic properties affect consumer acceptability, commercial value, and income of the fish farmer. Therefore, this research work is aimed at ascertaining the effect of different wood sources (Neem, Gmelina, and African velvet tamarind) on the organoleptic properties and shelf life of smoked *Clarias gariepinus*.

MATERIALS AND METHODS

Study area

The study was carried out in the Fish Processing Unit of the Department of Fisheries and Aquaculture Management, Nnamdi Azikiwe University, Awka, Anambra State, South Eastern Nigeria.

Collection of firewood

The dry woods of the three plants were purchased from a local wood seller in Umuahia, Abia State. The choices of these woods were attributed to their availability, smoke concentration, pH, bacteriological stability, and high content of some phenolic compounds. The three different kinds of wood were dried for 1 month before being transported to the study area.

Fish sample collection and preparation

A total number of twelve mature *Clarias gariepin*us (6 males and 6 females) of an average weight of 1kg were purchased from Izundu fish farm Awka for the study. The fish were sacrificed, degutted, washed and prepared thoroughly, and arranged on a rack for smoking.

Smoking process

Three smoking kilns were used for fish smoking concerning the three different kinds of firewood used. The twelve fish were grouped into three groups with four fish in each group – Group A smoked on Neem wood fuel, Group B on Gmelina, and Group C on Tamarind wood. The woods were set up 30 minutes before smoking and allowed to smolder to charcoal. To control the excessive temperature in the kiln, the intensity of the heat was reduced by the intermittent withdrawal of some wood. At intervals, the fish under smoking were turned to different sides to enable even distribution of heat. After the smoking process, each of the samples was packed separately in a transparent plastic container and stored at ambient temperature (38˚F) with no preservative applied.

Storage trials

Insect and mold attacks were monitored during the storage periods on daily basis. Attacks by insects or moulds were determined according to the method of Khan and Khan (2001). Insect and mould attacks were evaluated by giving scores on a hedonic scale of 0 - 3. A numerical score of 0 meant there was no sign of infestation or damage, 1 for occasional infestation, 2 for noticeable consistent infestations, and 3 for heavy insect/mould infestations covering the whole fish. For insect infestation, a score of 3 and above meant rejection of the fish, and a score above 0 was the limit of acceptability for mould. Signs of mould attack were the limit of acceptability, while a score of 3 for insects was the limit of acceptability beyond which the fish would be rejected.

Organoleptic analysis

The appearance, aroma/odour, taste, and texture of the fish from different smoking sources were analyzed. A 10-man panel consisting of 5 staff and 5 students of the Department of Fisheries and Aquaculture, Nnamdi Azikiwe University, Awka was used. The sample products were scored using hedonics of:

1 = Excellent, 2 = Very Good, 3 = Good, 4 = Fair, 5 = Poor

Statistical analysis

The data collated was subjected to analysis of variance (ANOVA). Duncan's multiple range tests were employed to reveal significant differences among the treatment means at a level of $p < 0.05$.

RESULTS

Table 1 shows that there was no significant difference ($p<0.05$) in the means. The result of the organoleptic properties of *Clarias gariepinus* smoked with three different kinds of wood is shown in table 1. This study showed that the catfish smoked with the African velvet tamarind wood had the highest means score of appearance (4.20 ± 0.92^a), followed by that of Gmelina 2.90 ± 0.88^a) while the lowest means score was observed in the catfish smoked with Neem wood (2.00 ± 0.67^a). A similar result was obtained in fish smoked with velvet tamarind wood which recorded the highest mean score in both (4.30 ± 0.82^a), and taste (4.70 ± 0.67^a), while the lowest means score was observed in both aroma (3.00 ± 0.94^a) and taste (3.00 ± 0.67^a) of catfish smoked with Gmelina wood. It was also observed that catfish smoked with African velvet tamarind wood had the highest mean score of texture (4.10 ± 0.86^a) while those smoked with Gmelina and Neem wood recorded (2.90 ± 1.19^a) and texture (2.50 ± 0.85^a) respectively. The results indicated that there was no significant difference ($P>0.05$) in the effects of these wood types on the organoleptic properties assessed.

Table 1: Organoleptic properties of catfish smoked with different wood source

Parameters	Gmelina wood	Neem wood	African velvet wood
Appearance	2.90 ± 0.88^a	2.00 ± 0.67^a	4.20 ± 0.92^a
Aroma	3.00 ± 0.94^a	3.40 ± 0.84^a	4.30 ± 0.82^a
Taste	3.00 ± 0.67^a	3.00 ± 0.94^a	4.70 ± 0.67^a
Texture	2.90 ± 1.19^a	2.50 ± 0.85^a	4.10 ± 0.86^a

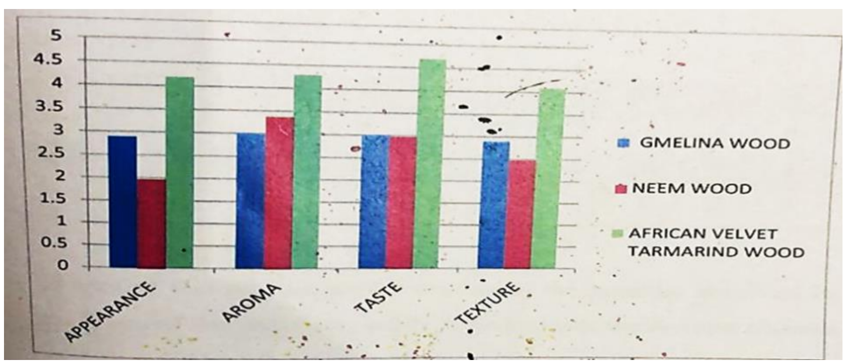

Fig. 1: Bar graph illustrating the organoleptic properties of fish smoked by the distinct medicinal woods.

Table 2 showed the results of insect attacks on catfish smoked with the three different kinds of wood after 48 days of storage. All the smoked fish samples had a score of 0.00, implying that there was no insect attack on the fish till the end of the study.

Table 2: Insect Score of catfish smoked with Gmelina, African velvet tamarind, and Neem woods

Parameter	**Week 1**	**Week 2**	**Week 3**	**Week 4**	**Week 5**	**Week 6**	**Week 7**
Gmelina wood	0.00	0.00	0.00	0.00	0.00	0.00	0.00
African velvet tamarind wood	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Neem wood	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 3 showed the results of mold attack on catfish smoked with the three different wood sources. Catfish smoked with Neem wood showed the highest severity to mold attack (3.00), followed by that of African tamarind velvet (1.00) while that of Gmelina wood showed no mold attack (0.00) after 48 days of storage.

Table 3: Mould score of catfish smoked with Gmelina, African velvet tamarind, and Neem woods

Parameter	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7
Gmelina wood	0.00	0.00	0.00	0.00	0.00	0.00	0.00
African velvet tamarind wood	0.00	0.00	0.00	1.00	1.00	1.00	1.00
Neem wood	0.00	0.00	0.00	2.00	3.00	3.00	3.00

DISCUSSION

The study assessed the organoleptic properties of medicinal woods (Gmelina, Neem, and African Velvet Tamarind) used in the smoking of catfish, as well as their effect on the shelf life of the fish. The organoleptic qualities (appearance, aroma, taste, and texture) of smoked fish, determines the acceptability to consumers and the market price of the fish. Table 1 expressed the choices made by the 10 panelists for this study. For all parameters assessed, fish smoked by African velvet tamarind *(Dalium guineense*) was adjudged to be the best.

The appearance, taste, aroma, and texture of fish smoked with tamarind velvet were better than other wood sources. The result of the African velvet tamarind wood source for the texture and aroma/flavor of fish in this work was similar to the work done by Agbabiaka *et al*., (2012). Catfish *(Clarias gariepinus*) smoked with Neem wood (*Azadirachta indica*), had the lowest mean score in terms of appearance and texture. This was in contrast to the work of Oduor-Odote *et al*. (2010), where fish smoked with neem wood maintained an above-average score for appearance. This can be attributed to the low burning intensity of the wood caused by the high moisture retention by the neem plant (Oduor-Odote *et al*., 2009). However, all the mean scores for taste and aroma/flavor in this study were above average for all wood sources.

Till the end of the research (48 days), there was no observable insect infestation on the fish smoked by the medicinal wood source in this study. The result was similar to the study of Oduor-Odote *et al*., (2010), where freshwater fish smoked by Neem wood experienced no insect infestation until after the 48th day. The result from this study can be attributed to the fact that these medicinal woods possess bioactive compounds which can be transferred to the fish through smoking, hence deterring insect infestation during storage.

Mould was first detected in fish smoked with African velvet tamarind wood and Neem wood on the 23rd day and 28th day (fourth week) respectively. This was in contrast to the work done by Oduor-Odote *et al*. (2010), where they first witnessed mold attacks on the 48th day. The catfish smoked with African velvet tamarind wood had a mild infestation with a score of 1.00, and there was no increase in mold infestation till the end of the experiment, while the fish smoked with Neem wood had a score of 2.00, which later progressed to 3.00 in the 5th week. There was no evidence of mold attack in the fish smoked by Gmelina wood for the first five weeks of storage but a little infestation of mold was observed in the fish with a score of 1.00 in the sixth week. There was however no literature on the use of Gmelina wood in smoking fish for the assessment of mold attack. Mold attack on the fish might be attributed to the temperature and humidity of the storage environment. Agbabiaka *et al.* (2012) reported that the wood used for smoking fish might contain natural chemical compounds (phenols, carbonyl, and syringol) which are responsible for the pleasurable taste, color, and flavor in the smoked product.

CONCLUSION

According to the findings of this study, processing fish using medicinal woods obtained from Neem, Gmelina, and African velvet tamarind is effective in improving the organoleptic properties of the smoked catfish as well as extending their shelf-life. The result also showed that fish smoked with African velvet tamarind wood was the most preferred in terms of all the parameters assessed suggesting that African velvet tamarind wood should be adopted for fish smoking.

RECOMMENDATION

All fish smoked with the medicinal wood exhibited an insect-deterring effect on the fish; this suggested that these woods can be adopted in aquaculture as a means of smoking to improve the shelf-life of fish, hence increasing profitability. In addition, there should be more research on other woods of medicinal plants for smoking fish.

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Effect of Charcoal on Soil Physico-Properties in Ndele, Rivers State: Implication for Organic Farming

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ABSTRACT

The study was aimed at evaluating effect of charcoal on the Physico-chemical properties of Ndele soil .The study was conducted during the first farming season at the Teaching and Research Farm Ignatius University of Education Ndele Campus. The design adopted was randomized complete block design (RCBD) , topography was block , five treatments, 0,2, 4,6 and 9 tonsha-1 charcoal . The experimental area was cleared, seed beds were constructed before grounded charcoal was measured and applied in each of the experiment units and each treatment was replicated three times. The duration for experiment was six weeks and soil samples were collected using soil augur at the depth of fifteen centimeters (15cm). The collected samples were taken to laboratory for analysis. The data generated were subjected to analysis of variance using SPSS version and means separated with Duncan multiple range test. It was observed that organiccarbon, moisture, phosphorus (P), Manganese (Mn), Magnesium (Mg) and Iron (Fe) content of the soil increase as the level of treatment increased from 2 ton ha-^{1} to 6 tons ha^{-1} charcoal. Potassium (P), Zinc (Zn) Calcium (Ca), Boron (Bo) and Chlorine (Cl) content of the soil reduce as the quantity of treatment increased. It was also observed that Fe was not significantly ($p \leq 0.05$) different among treatments .Higher treatment 8 tons ha^{-1}had no significant effect on Physico- chemical properties measured. Finally it was observed that the range of 4 tons ha^{-1} and 6tons ha^{-1}charcoal gave the best concentration of the tested Physico- chemical properties of the soil. It concluded that charcoal should be used to improve the fertility of the soil in Ndele but higher application of 8 tons ha-^{1} should be avoided.

INTRODUCTION

Man has direct and indirect relationship with soil. Animals including man feed from plant that utilizes soil nutrients. The nutrients by nature are subject to depletion over time as a result of utilization.This depletion may also influence other physical and chemical properties of the soil. According to O'Neil *et al.* (2009), as the content of soil organic matter decreases, the bulk density of soil also decreases. Bulk density and course fragments are integrated into a soil quality. Furthermore, from the study of soil properties such as the soil texture of soil, depends on the amount of the sand or clay or silt particles, the most advantageous physical properties of soil is soil texture, the reason being that all necessary components including soil nutrient, water and aeration are mostly dependent on it(O'Neil *et al*. 2009),.Similarly, writing on the chemical properties of soil, Nelofer *et al* (2016), reported that it is very difficult to discriminate between chemical, physical and biological properties of soil. Because of vivacious inter – link with each other. For Bockheim (2015), the soil quality indicators like chemical and biological properties have prominent connection between them. Many researchers consider the similar attribute in any sort. According to him the Physico-chemical properties of soil is directly affected on all those microbiological properties that can encourage the water holding capacity, nutrient cycling, accessibility of water, pH buffering, leaching and ion exchange capacity of soil. According to Bockheim (2015), chemical indicators of soil are same for farming and woodland soils. Schaetzl and Thompson, (2015), reported that soil organic matter is also a major key chemical indicator for assessing soil quality and in aggregate stability. To them soil chemistry determines the availability of nutrients, microbial growth, corrosively and stability of water it should therefore be concluded that physical and chemicalproperties of soil are significant and the components that are a combination of characteristics including soil carbon and soil quality index.

Today, sustainable agriculture or farming totally or partially nullifies the use of agro- chemicals because of their long term effect on the ecosystem and man (Food and Agricultural ORganisation, FAO, 2016; Urban2008). Organic agriculture is a holistic production management system which promotes and enhances agro-ecosystem health, including biodiversity, biological cycles, and soil biological activity (FAO,2016; Littcerick and Watson,2017). It emphasizes the use of management practices in preference to the use of off-farm inputs, takinginto account that regional conditions require locally adapted systems. This is accomplished by using, where possible, agronomic, biological, and mechanical methods, as opposed to using synthetic materials, to fulfill any specific function within the system (Codex, 2007).Organic farming implies recycling of waste and residue to the native soil itself, replenishing the nutrients depleted from the soil during the crop growth, encouraging the growth of microorganisms which could regulates phased release of stored nutrients in the soil to the crop growth in right proportion, maintaining soil health by balancing the soil moisture and soil aeration and ensuring soil fertility by firmly binding the nutrient elements in the complex organic molecules (Patel, Choudhary andSwarnakar, 2013). Organic farming implies zero agro-waste, waste from a particular farm produce is a start off pack in another produce. Organic farming has numerous advantages to ecosystem and man; it improves the soil fauna and flora thereby enhancing soil performance and fertility; reduces pollutions and prevents man from suffering residual health effect of harmful substances.

There are numerous organic resources that may be used to fortify or amend the soil, one of which is charcoal. Charcoal a product of partial or complete combustion of wood. It is very common in communities where energy or fuel wood is used for cooked. It is also common in areas where traditional farm still persist, clearing and burning farm land lead to charcoal production and crop are sowed with them on farmlands. Some farmers are commonly seen in local community burning wood on special site for special crops such as pepper, cucumber and amarathus to mention but a few .

Charcoal works as a highly effective slow release fertilizer. According to Keller (2017), the type of charcoal used, however, is important; emphasizing that natural charcoal formed from biomasses such as wood will give the best results. This natural charcoal from natural alternative outlets or made by slow - burning wood will release vital nutrients into the soil aiding the growth of plants (Keller, 2017). The importance of charcoal dates back to its use as fuel for cooking and steam engines etc. However, Glaser *et al.* (2001), reported that charcoal apart from its primary function as fuel, it has long ago been used as a soil improver in many parts of the world. But Nishio and Okaw (1991), reported that only recently was the application of charcoal to the soil practiced. According to Ogawa andOkimori (2010), the effects of charcoal vary according to the raw materials, production methods and types of charcoal and the period of its application to the soil. For them bio-char shows a positive effect on certain physical, chemical and biological properties of soils. Laird *et al*, (2010), reported the advantages of charcoal, emphasizing that because charcoal been a porous material with high water and air retention capacities, its addition to agricultural soils leads to increases in water holding capacity and decreases in nutrient leaching. Steiner *et al*, (2007) reported that less attention was given to quantifying nutrient leaching from agricultural soils treated with charcoal despite the fact that a lot of plant and soil scientists' have recommended the use of charcoal for soil improvement, and to achieve better plant growth. According to Steiner *et al,(*2007), a review of literature showed no previous comparative study of the most suitable quantity of charcoal grains to simultaneously promote plant growth and reduce nutrient leaching. For Major *et al* (2009), nutrient leaching and retention of agricultural land is greatly influenced by soil texture. Ketterings and Bigham (2000), reported that charcoal addition to the soil have positive effect on soil properties and enhance soil fertility and productivity. For Glaser *et al*, (2002), increased soil acidity pH, addition of free bases such as ca, k, and mg and enhancement of the cation exchange capacity showed that added charcoal is not only a soil conditioner but also acts as a fertilizer. In addition, putting charcoal to the soil will positively affect seed germination, crop growth and yields (Ketterings and Bigham 2000). Glaser *et al*, (2002), in a recent review demonstrated that crop yields can be increased when chemical is added to the soil especially in the tropics. The significance of charcoal to plant growth is so much that apart from increasing the amount of water a soil can hold and improvement to soil acidity pH) so that plants can get more nutrients from the soil, evidences show that charcoal which has tiny pores that looks like sponge can equally absorbs pesticides and chemicals secreted from the roots of anxious weeds and enhance special fungi that infect a plant root and assist the plant to get more nutrient from the soil. The soil in Ndele has been continuously expose to gents of soil degradation factors and nutrient losses such as rainfall, leaching, erosion, nutrient uptake by plants and crop removal . Therefore, the study was aimed at determining the effect of charcoal on the Physico-chemical properties of the soil.

MATERIALS AND METHODS

The experiment was carried out at the Teaching and Research farm of IgnatiusAjuru University of Eduction, NdeleCompus in 2022 and the experiment lasted six (6) weeks. The design of adopted was complete randomized block design (CRBD) with five (5) treatments replicated three (3) times. The land was cleared mapped out and seed bed constructed. The bags of charcoal were purchased from local producers, grounded, measured and applied on the seed beds. The treatments applied were 0, 2, 4, 6 and8ton ha-1. The soil samples were collected for Physico- chemical properties test of the soil 6 weeks on application of the treatments using soil auger at a depth of 15 cm and taken to the laboratory for analysis using standard procedures. The Physico-chemical properties test for were pH, moisture, organic carbon,P,K,S,Zn,Mn, Cu,Fe,Bo and Cl of the soil. The generated data were subjected to analysis of variance and mean separated using Duncan Multiple RangeTest (DMRT).

RESULT AND DISCUSSION

Table 1 showed the summarized effect of different rate of application of charcoal on soil Physico-chemical properties of the soil.The organic carbon content was 34.45, 47.99, 47.50, 48.30% and 43.18 for 0,2,4,6 and 8 tonha-1 of charcoal respectively

Table1 Effect of Charcoal Application on soil Physico-chemical Properties

Charcoal Rates	OC	pH	Moisture	Total N	P	K	Ca	Mg	S	Zn	Mn	Cu	Fe	Bo	Cl
O	34.43^{a}	5.25^{a}	16.03^{a}	13.68^{d}	0.15^{a}	0.80^{b}	0.73^{b}	0.06^{a}	0.049^{b}	0.10^{a}	0.036^{a}	0.42^{c}	3.79^{a}	0.083^{a}	0.176^{b}
2 ton	47.99^{c}	5.67^{b}	16.50^{a}	13.94^{e}	0.15^{a}	0.81^{b}	0.74^{b}	0.06^{a}	0.011^{a}	0.093^{a}	0.039^{a}	0.146^{c}	4.24^{a}	0.083^{a}	0.152^{b}
4 ton	47.50^{c}	5.77^{b}	16.60^{b}	13.33^{b}	0.17^{a}	0.79^{a}	0.73^{b}	0.059^{a}	0.11^{a}	0.073^{a}	0.038^{a}	0.130^{b}	4.29^{a}	0.070^{a}	0.139^{a}
6 ton	48.30^{c}	5.77^{b}	16.60^{b}	13.16^{a}	0.18^{a}	0.77^{a}	0.73^{b}	0.055^{a}	0.012^{a}	0.077^{a}	0.038^{a}	0.130^{b}	4.12^{a}	0.080^{a}	0.110^{a}
8 ton	43.18^{b}	6.25^{c}	17.39^{c}	13.52^{c}	0.16^{a}	0.77^{a}	0.57^{a}	0.251^{b}	0.074^{b}	2.57^{b}	0.033^{a}	0.100^{a}	4.14^{a}	0.25^{b}	0.215^{c}
SE df=14	3.68	0.285	0.033	0.079	0.12	0.009	0.003	0.043	0.016	0.554	0.003	0.012	0.21	0.27	0.022

Mean with same superscript is not significantly different (0.≤05)ph,N,P,K,Ca,Mg,S,Zn,Mn, Cu,Fe,Bo,Cl means soil pH, nitrogen, phosphorus, potassium, calcium, magnesium, sulphur, zinc, manganese, copper, iron, boron and chlorine respectively.

The organic carbon content of the soil showed a numerical increase in the treatment rates of charcoal from the control (0ton) to 6 tons per hectare which were significantly different at 0.05. Treatments 2, 3 and 4 were not significantly different and treatment 1 and 5 were not significantly different. The observed pattern may be due to the following factors / method of processing, age of trees and charcoal, handling procedures and season of application of the charcoal.

The pH of the soil for charcoal treatment rates are 5.77, 5.67, 5.25, 5.77 and 6.25 respectively for 0, 2, 4, 6 and 8 tonsha^{-1}of charcoal. The charcoal treatment rates were significantly different P≥0.05, 0 and 2 tons ha^{-1} application were not statistical different but showed numerically deduction pH of the soil as the application increases from 0ton (control) to 4 tons ha^{-1} and the pH rises again from 6 tons ha^{-1} that is from 8.25 when 4 ton ha^{-1} was applied to 5.77 and 6.25 respectively for 6 and 8 tons ha^{-1}. This indicates that higher application may change soil to slightly acidity instead of alkaline

The soil water holding (content) capacity for charcoal treated soil are 16.60, 16.50, 17.39, 16.50 and 18.03 respectively for 0, 2, 4, 6 and 8 tons ha^{-1}. There is no significant difference among treatments. The soil water holding at 4, 6 and 8 tons ha^{-1} of charcoal treatment were higher than numerically than 0 and 2 tonsha^{-1} treatments respectively. It could be deduced that charcoal has poor ability to absorb water from the air to soil. Total nitrogen of the treated soil is 13.68, 13.94, 13.33, 13.16 and 13.32 for 0, 2, 4, 6 and 8 tonsha^{-1} of charcoal. There was numerical increase in the total nitrogen of the soil among treatments. These numerical increase were significant (P≤0.05). The soil phosphorus (P) is 0.16, 0.15, 0.17, 0.18 and 0.16 ppm for 0, 2, 4, 6 and 8ton ha^{-1} of charcoal. There was numerically a difference as a result of quantity applied but there was no significant difference. The soil potassium (K) are 0.80, 0.81, 0.79, 0.77 and 0.71 ppm for 0, 2, 4, 6 and 8 ton-ha of charcoal. The soil potassium for treatments 0 and 2 ton/ha^{-1} of charcoal were not significant but significantly different for 4, 6 and 8 tons ha^{-1} were not significantly different from each other. The soil calcium (Ca) are 0.73, 0.74, 0.73, 0.75 and 0.57ppm for 0, 2, 4, 6 and 8 tons/ha of charcoal respectively. There was significant difference among treatments. Treatment 0, 2, 4 and 6 tons/ha were not significantly different but significantly different from treatment 8 ton/ha of charcoal. Magnesium (Mg) due to charcoal application is 0.066, 0.59, 0.055 and 0.25 ppm for 0, 2, 4, 6 and 8 tons ha^{-1} respectively. Application of charcoal led to reduction in quantity of Mg.

Charcoal application indicates the soil sulphur (S) as 0.049, 0.011, 0.012 and 0.074ppm for 0, 2, 4, 6 and 8 tonsha^{-1}. The application showed initial reduction in soil sulphur from 0.049ppm in 0ton ha^{-1} to 0.011ppm in 4kgha^{-1} of charcoal. There was an increase in quantity of S from application of 6tons ha^{-1} to 8 tons ha^{-1}

Zinc (Zn) content of soil due to charcoal application indicates 0.10, 0.093, 0.073, 0.077 and 2.57 ppm 0, 2, 4, 6 and 8 tons ha^{-1}. The application of charcoal reduces the quantity of 2 in the soil from 0.10 ppm in 0 ton ha^{-1} to 0.077 ppm in 6 tons ha^{-1} but 8 tons/ha^{-1} shows 2.57 ppm. There was no significant difference among 0, 2, 4 and 6 tons ha^{-1} of charcoal but differ from 8 tons/ha^{-1}. It could be deduced that higher application of charcoal from 8 tons ha^{-1} could be beneficial to soil Zn.

Mn content of the soil treated with charcoal indicates 0.036, 0.039, 0.038, 0.038 and 0.033 ppm for 0, 2, 4, 6 and 8 tons ha^{-1} respectively. There was both increment and reduction as the application quantity increased Mn increases from 0.036 ppm application. From there, reduction was observed as 4, 6 and 8 tons ha^{-1} were applied. The various treatments 0, 2, 4, 6 and 8 tons/ha^{-1} were not significantly difference. This may show that charcoal is very low in Mn and could also prevent reaction which involves mobilization of Mn from the soil for crop uses.

Copper (Cu) content of soil as treated by charcoal indicates 0.142, 146, 0.130, 0.130 and 0.100 for 0, 2, 4, 6 and 8 tons ha^{-1} respectively. Application of charcoal led to the initial increase in the quantity of Cu, from 0.142 ppm in the control to 0.146 ppm in the application 2 tons ha^{-1}. When 4 tons ha^{-1} is applied, there is a reduction in quantity of Cu to 0.130 ppm and continued application of 8 tons ha^{-1}indicates 0.100 ppm of Cu. There was a significant difference among treatments. Control (0 tons ha^{-1}) and treatment of 2 tons ha^{-1} do not differ significantly. In similar way, 4 tons ha^{-1} and 6 tons ha^{-1} do not differ significantly. The observed may be due to the soil reactions which immobilized Cu.

Iron (Fe) content of the soils treated with charcoal indicates as3.79,4. 24,4.29, 4. 12 and 4.14 ppmfor 0, 2, 4, 6and 8 tonsha^{-1}respectively. The application of charcoal showed initial increase in the Fe of soil but higher application above 4 tons ha^{-1} led to reduction in the soil Fe. The increase or reduction due to application was not significantly different. It could be reduced moderate application of charcoal could be applied to soil. The application of charcoal indicates the Bo content of treated soils as 0.083, 0.083, 0.070, 0.074 ppm and 0.25 for 0, 2, 4, 6 and 8tons ha^{-1} respectively. The increase in the Bo level was not uniform but there was a significant difference among treatments. Treatments 0, 2, 4 and 6 tons ha^{-1} are not significantly different.

Chlorine (Cl) content of soil indicates 0.176, 0.52, 0.139, 0.110 and 0.215 ppm for 0, 2, 4, 6 and 8 tons ha^{-1} of charcoal treatment. There was gradually reduction in the Cl content of the soil from control to 6 tons ha-1then increase to 0.215 ppm for 8 tons ha^{-1}

There was gradual increase in organic carbon, soil pH, total nitrogen moistureandmineral were positively increased. Organic carbon content of the soil though increase was not significant among treatments. Total nitrogen, moisture, pH and mineral in the soil are major indicators of soil fertility. Soil fertility is built with these components substances and is derived from organic and chemical sources. These findings are in consonant with the report of Nelofer *et al*. (2016),that the Physico-chemical properties of the soil determine the comfort easily uptake water by plants volume of oxygen and other gases and their movement with the soil. These findings are similar to the report of Kelterings and Bigham (2000) that charcoal addition to the soil have positive effect on soil properties and enhance soil fertility and productivity. The findings are also in line with result from Bijisma and Lambers (2000) who reported that charcoal introduction into the soil affects the amount of mineral nitrogen, organic carbon availability of the soil. The results also reflect the report of Aduayi *et al.* (2002) that the major elements in fertilizer are known to be deficient in most Nigeria soils.

CONCLUSION

From data analyzed, the application of charcoal has positive influence on soil Physico –chemical properties. Application of 4tons ha-1 of charcoal improves the organic content, soil acidity structure, texture and nutrient contents of Ndele's soil. It is recommended that charcoal should be applied at least 4 to 6 tonsha^{-1} to fortify the soil Physico-chemical properties and enhance crop yield in eroded soil like Ndele. Also charcoal should be used as substitute for NPK or any other organic fertilizer.

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Effect of Different Mulch Materials on Soil Properties, Growth and Yield of Tomato (*Lycoperiscon esculentum* mill) at Awka, Southeastern Nigeria

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K E Y W O R D S

Mulch materials,
f1 hybrid,
Padma 108,
East west tomato seeds,
Plastic mulch,

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A B S T R A C T

The experiment was conducted at Soil Science and Land Resources Management Research Farm, Nnamdi Azikiwe University, Awka, to study the effect of different mulch materials on selected soil properties, growth and yield of tomato. The treatment consisting of four mulch materials (sawdust, rice husk, plastic mulch, dry grasses and a control) were evaluated with Randomized Complete Block Design (RCBD) in four replications. Padma 108 f1 hybrid east west tomato seeds were used in the investigation. Data collected were subjected to Analysis of variance (ANOVA) and the means separated using Fishers Least Significant Difference (FLSD) at 5% level of significance. The results of the study indicated that using plastic mulch to grow padma 108 f1 hybrid east west seeds variety for tomato production in the area gave higher yield compared to other treatments. Therefore, application of plastic mulch for tomato production using padma 108 f1 hybrid east west seeds is recommended for tomato producers in the study area. Observations were made on plant height, number of branches, number of leaves, % flowering, % fruiting, which increased on mulched plots than on the control. Soil laboratory results showed that soil pH, soil organic carbon content, available phosphorus and exchangeable cations (Ca, K, Mg, and Na) increased as a result of increase in organic matter with the application of the mulch. Organic mulch precisely Dry Grasses improved the physical properties of the soil.

INTRODUCTION

Mulching is used to regulate and control the soil temperature, moisture and nutrient content (Aldefer, 2005), weeds, pests and diseases (Unger *et al* 2001). It is known that plant development and yield increase occur with balanced soil temperature; mulching play great role in increasing yields, promoting early harvest, reducing fruit defects, reducing evaporation from the soil surface in vegetable production (Splittstoesser, 2005). The effectiveness of mulching depends on the type of mulching materials used. Mulches can be categorized as organic or inorganic (Forge *et al*. 2002), depending on the composition of the mulch, and their different effects on the growing medium. Effects of mulching include increase in specific mineral such as N, K, Mg, Ca, etc. in the soil as the mulch decomposes as well as changes in soil pH. Areas with sandy soils, which are more acidic than heavier soils, can thus benefit from the use of mulch as a possible contribution of organic material to the biological component of the soil environment (Forge *et al*. 2002). In addition, some mulches buffer changes in moisture, which will also have an influence on the soil micro-organisms (Autio *et al*. 1991; Brown and Tworkoski, 2003; Arancon *et al*. 2006). Mulching inhibits direct contact of the plants leaves and fruits with the soil, thereby producing cleaner crops with less decay potential.

Tomato is one of the major vegetables in Nigeria, hence, its use as a test crop in this study. Successful tomato cultivation largely depends on the cultural optimum efficient use of available soil moisture, spacing, time of planting, management practices etc. Tomato has best yields when grown in well-drained loam soils, rich in organic matter and plant nutrients with a pH range of 6 to 7.

Paucity of documented information on mulching and its influence on soil properties and tomato production especially in southeastern Nigeria has necessitated this study to be designed to focused on the positive effects of mulches in increasing the organic matter content in the soil (Arancon *et al*. 2006), increase soil moisture, moderate soil temperature (Treder *et al*. 2004), and improve root growth (Acharya and Sharma 1996). Mulches differ significantly in terms of the above mentioned positive attributes (Walsh *et al*. 2005).

The objective of this study is to examine the effect of the different mulching materials on selected soil properties, growth and yield of tomato in Awka.

MATERIALS AND METHODS

Description of the Experimental Site

The experiment was carried out at the Soil Science and Land Resources Management Research Farm, Faculty of Agriculture, Nnamdi Azikiwe University, Awka in the year 2015/2016. Awka is located at latitude 7°00 and 7°10'N; longitude 6°5' and 6°15'E at an elevation of 447 m above sea level. The site is characterized by heavy rainfall which is bimodal and high humidity (70 – 80%) (Ezenwaji *et al*., 2014).

Design and Layout of the Experiment

A total land area of $5000m^2$ was manually cleared, ploughed and harrowed by tractor and the beds raised according to specifications. Tomato seedlings were transplanted at a spacing of 60 by 50 cm. The experiment was laid out in Randomized complete block design (RCBD), having five treatments and four replicates. The treatments were: Black plastic mulch (M2); Rice husks (M5); Dry grasses/hay (M4); Saw dust (M3); Control (M1), which were replicated 4 times

Cultural and Management practices

Mulch Materials were applied at a thickness of 0.2mm per plot. Pyramidal staking was done 18 DAT; NPK (15:15:15) was applied at 1 week after transplanting (WAT); weeding operation was carried out at 2 weeks interval. The crops were harvested at intervals of two days

Soil Sample Analysis

Six initial Soil samples were collected at 0-15 cm depth and composited. At harvest (8-12 weeks after application of mulch), soil samples were collected at designated points, air-dried, ground, passed through 2 mm sieve and stored in plastic bottles, ready for analysis. The samples were analyzed for pH using pH meter (McLean, 1982), Soil texture was determined by Bouyoucos hydrometer method (Gee and Bauder, 1986); Soil moisture was determined by gravimetric method (Jalota *et al*., 1998), bulk density was determined using core method (Blake and Hartge, 1986), soil organic carbon was determined using Walkley and Black wet oxidation method (Nelson and Sommers, 1982); Total N by Bremner and Mulvancy (1982). Phosphorus (P), calcium (Ca^{2+}), magnesium (Mg^{2+}) and potassium (K^+) were extracted with 1.0N NH4OAc. Available P was measured using spectrophotometer (Nelsen and Sommers, 1982), K was determined using flame photometer (Richards, 1954). Ca and Mg were determined using the EDTA filtration method.

The following growth and yield parameters were collected:

Plant height was measured using meter rule; Number of Branches and Number of the Leaves by visual counting and observation.

Data Analysis

Data collected were subjected to analysis of variance (ANOVA) following the routine procedure for RCBD experiments using GenStat 2008 edition (GenStat, 2008). Mean separation was done using Fisher's least significant difference (F-LSD) at 5% probability level.

RESULT AND DISCUSSION

Table 1 showed the results of initial soil sample to assess the soil fertility status. Soil organic carbon was 1.23%. Available phosphorous was 20.6 (ppm) while soil Ca^{2+} and Mg^{2+} were 10.9and 5.44 (meq 100 g–1 of soil) respectively. The soil was slightly acidic with a pH of 6.2. The soil texture was sandy loam.

Table 1: Pre-planting soil physico-chemical properties of the experimental site

Soil property	Values
(%) Sand	69.22
(%)Clay	4.54
(%)Silt	26.24
pH	6.2
Bulk density mg/ cm^3	1.61
Moisture content (%)	11.49
Total porosity (%)	39.25
Organic carbon (%)	1.23
Available P (ppm)	20.6
Exchangeable K (meq 100 g^{-1} soil)	10.83
Exchangeable Ca (meq 100 g^{-1} soil)	10.9
Exchangeable Mg (meq 100 g^{-1} soil)	5.44
Exchangeable Na^+(meq 100 g^{-1} soil)	14.0
Exchangeable H^{2+} (meq 100 g^{-1} soil)	8.0
Exchangeable Al^{3+} (meq 100 g^{-1} soil)	9.0

Table 2 showed the effect of mulch treatments on soil chemical properties. Organic carbon, $Ca^{2+,}$ Mg^{2+} and H^+were not significantly different from the control. This result is expected, because plastic mulch promotes the respiration of roots and soil microorganisms, accelerates the decomposition of organic matter, and increases the concentration of carbon dioxide in soil thereby increasing available P content (Gu *et al*., 2018; Zhang *et al*., 2020).

The pH differed significantly and followed the order: rice husk (5.8)> saw dust (5.6)> plastic mulch (5.4)>dry grasses (5.2)>control (4.8). The increase observed in soil pH value could probably be due to significant improvement in soil organic matter and exchangeable cations. Available Phosphorus was in the order: Black plastic (0.060 ppm)>Dry grasses (0.042 ppm)>Saw dust (0.025 ppm)>Rice husk (0.036ppm)>control (0.24 ppm). A report by Hundal *et al*. (2000) indicated that available phosphorus was significantly affected by mulching. The increase in available P in the mulched plots could be attributed to the increase in soil organic matter. Sanchez (2001) observed that maintaining organic matter could affect phosphorus level. However, the decline in available P in the control could be as a result of plant uptake and P-fixation without replacement because many studies have demonstrated that mulching significantly affected the available P in different soil depths and surfaces (Thankamani *et al*., 2016). Qu *et al*. (2019) indicated that available phosphorus content was significantly affected only by the organic mulches. K was observed to vary significantly among the treatments. Plots mulched with Plastic and dry grasses were significantly different from control which was statistically the same with rice husk and saw dust. K decrease under control could be attributed to removal through plant uptake and losses through leaching. The increase in K with time on mulched plots could be a result of the increase in organic matter derived from mulching.

Na^+ was observed to vary significantly among the treatments. Plastic mulch, Rice husk and saw dust were significantly different from the control which was statistically the same as dry grasses. Meanwhile, Saw dust had the highest value (1.8) while plastic mulch had the least (0.18).

Table 2: The effect of mulch treatments on soil chemical properties

				Exchangeable bases					
Treatment	**Org. C %**	**pH**	**Ava. P (ppm)**	K^+ (meq 100 g–1 of soil)	Ca^{2+}	Mg^{2+}	Na^+	Al^{3+}	H^+
Plastic mulch	1.24	5.4	0.061	2.21	17.1	8.6	0.18	0.7	0.4
Dry grasses	1.53	5.2	0.042	2.20	18.2	9.1	0.29	0.2	0.4
Saw dust	1.89	5.6	0.025	1.28	15.7	7.8	1.8	0.5	0.4
Rice husk	1.32	5.8	0.036	1.41	18.0	9.0	0.19	0.1	0.3
Control	1.30	4.8	0.024	1.39	15.5	7.8	0.22	1.4	0.6
LSD0.05	NS	0.011	0.02	0.03	NS	NS	0.041	0.037	NS

P value <0.05; NS means Not Significant

Table 3 showed the effect of mulch treatments on soil physical properties. Mulch significantly affected soil moisture content. Dry grasses (14.94) varied significantly with control (11.85) which was statistically the same as Plastic (12.88), saw dust (12.79), Rice Husk (12.49). It was observed that Soil moisture content improved considerably due to the decreased temperature in plots mulched with dry grass. The result agrees with the findings of (Adeoye, 1984; Agele *et al*., 2000) who reported the effect of mulching on soil moisture conservation and reduction in soil temperature regimes. Organic mulch precisely, Dry Grasses reduced evaporation of soil moisture and thus improved soil moisture retention (Hernandez *et al*., 2016). Other studies from agricultural fields in the humid tropics had shown that mulching ameliorates soil moisture deficits and regulates temperature regimes, improves water infiltration, reduce evaporation and run–off as well as improve soil structure (Olasantan, 1988) This is in agreement with Smith *et al*. (2000), findings; Liu *et al*. (2002) and Khurshid *et al*. (2006) who observed that mulching improved the ecological environment of the soil and increased soil water content.

For bulk density, Dry grasses (1.30) varied significantly with control (1.48) which was statistically the same with rice husk (1.39), saw dust (1.36) and plastic mulch (1.38). From the result we observed that organic mulch reduced the bulk density of the soil when compared to the control. This agrees with the findings of Ghuman and Sur (2001) who concluded that mulching decreased bulk density of the surface soil. According to Aina (1979) organic mulch eliminates compaction in soils. According to Fergusen and Gumbs (2000), Mulching reduced bulk density, increased soil moisture, organic matter contents leading to suitable environment for **root penetration.**

Table 3: Effect of mulch treatments on soil physical properties

Mulch	Textural Class	BD mg cm^{-3}	Soil Porosity (%)	Moisture Content (%)
Plastic Mulch	Sandy Loam	1.38	40.09	12.88
Dry Grasses	Sandy Loam	1.30	37.63	14.94
Saw Dust	Sandy Loam	1.36	41.0	12.79
Rice Husk	Sandy Loam	1.39	40.93	12.49
Control	Sandy Loam	1.48	37.29	11.85
$LSD_{0.05}$	-	0.04	0.03	0.03

P value <0.05.

Table 4 showed the effect of the different mulching materials on tomato branches at 2, 4 and 6 weeks after transplanting (WAT). At 2 weeks, there was significant difference ($p<0.05$) among the mulched materials with respect to the number of branches produced by the tomato plants. Number of branches was in this order: black plastic (10.67)>Dry grasses (9.50) > Rice husk (9.33)>Saw dust (9.17) >control (7.92).

At 4 weeks, there was significant variation ($p<0.05$) in the number of branches produced. It was in the order: plastic mulch (24.67)> Rice husk (19.42)> Saw dust (17.67)> Dry grasses (17.17) and then control (12.75).

At 6 weeks, there was a significant difference in tomato branches. It followed this pattern: Plastic (39.42)>Dry grasses (31.75)> Rice husk (31.00)> Saw dust (29.42)> Control (22.42). This observation pattern at 6WAT is exactly the same with the observation at 2WAT. The number of branches per plant continually increased with plant age. All the mulches had positive effect on generating and retaining higher number of branches per plant. Generally, the highest number of branches per plant was observed in black plastic mulch. Control always showed the least number of branches. It was reported that mulched tomato plants had more branches than that of the control, which supported these results (Srivastava *et al*., 1994). The least number of branches recorded under control might be due to soil temperature difference among mulch materials. The increase in plant branches due to the various mulch materials has been reported by Taber and Smith (2009), which corroborates with our findings.

Table 4: Effect of mulching materials on number of tomato branches at 2, 4 and 6 weeks after transplanting

	Weeks after transplanting (WAP)		
Treatment	2	4	6
Plastic mulch	10.67	24.67	39.42
Dry grasses	9.50	17.17	31.75
Rice husk	9.33	19.42	31.00
Saw dust	9.17	17.67	29.42
Control	7.92	12.75	22.42
$LSD_{0.05}$	1.26	4.74	5.84

Table 5showed the effect of the different mulching materials on the number of leaves at 2, 4 and 6 weeks after transplanting. At 2 weeks after transplanting, there was a significant difference ($p<0.05$) in the number of tomato leaves. The order was: Black plastic (106.9)>Saw dust (99.2)>Dry grasses (88.3)>Rice husk (79.8) and then the control (75.8).

At 4 weeks after planting, the different mulching materials had a significant variation ($p<0.05$) on the number of leaves. Black plastic (223.8)>Dry grasses (213.5)>Saw dust (209)>Rice husk (200.7)>control (165.6).

At 6 weeks after transplanting, there was a significant difference ($p<0.05$) in the number of tomato leaves as a result of the different mulching materials used. Black plastic (272.1)> Dry grasses (255.1)>Saw dust (248.2)>Rice husk (241.6)>control (199.0).

The maximum number of leaves per plant was found on the plants mulched with black plastic at all growth stages, followed by the Dry grasses. The microclimate condition improved by the mulches might have provided a suitable condition for producing higher number of leaves in the plants. The effectiveness of plastic mulches for the production of leaves in maize was better than control as reported by Izakovic (1989). The number of leaves increased with increasing time after transplanting. The greater number of leaves might be due to the optimum soil temperature and higher soil moisture content at the root zone during the plant growing period.

Table 5: effect of different mulching materials on the number of tomato leaves at 2, 4 and 6 weeks after transplanting

	Weeks after planting		
Treatment	**2**	**4**	**6**
Plastic mulch	106.9	223.8	272.1
Dry grasses	88.3	213.5	255.1
Rice husk	79.8	200.7	241.6
Saw dust	99.2	209.0	248.2
Control	75.8	165.6	199.0
$LSD_{0.05}$	19.06	41.03	40.93

Mulching also helps to balance soil temperature; this in turn affected soil microbial activities in the rhizosphere (Ayum *et al*., 2008). It prevents crops from rainwater splash thereby maintaining plant hygiene (Johnson *et al*., 2004). Enhanced microbial population increased plant growth parameters which eventually increased the yield of the plant (Bhagat *et al*., 2016).

Table 6 showed the effect of different mulching materials on plant height at 2, 4 and 6 weeks after transplanting. Observed results showed that there were significant differences ($p<0.05$) in the height of tomato plants at 2, 4 and 6 weeks after transplanting. Black plastic mulch (42.17cm)>Dry grasses (39.33cm)>saw dust (36.50cm)>Rice husk (32.67cm)>control (32.00cm).

At 4 weeks after transplanting, there was a statistically significant difference ($p<0.05$) in height of tomato plants. Black plastic mulch (81.3cm)>Saw dust ((72.6cm)>Rice husk (64.5cm)>Dry grasses (63.4cm)>control (55.6cm).

At 6 weeks after transplanting, significant differences ($p<0.05$) were also observed in tomato plant height. Black plastic (93.5cm)>Saw dust (86.8cm)>Rice husk (77.6cm) >dry grasses (74.6cm)>control (70.0cm).

Height of tomato was observed to be higher in mulched plots than in the control. This effect might be due to conservation of sufficient soil moisture which provided water to the plant. On the contrary, control did not have much height possibly due to volatilization of soil nutrient/moisture. The increase in plant height due to various mulch materials have been reported by various authors (Bhardwaj, 2011; Sarolia and Bhardwaj 2012). Synthetic mulches increased plant height over the control (Ekinci and Dursun 2009). The increased plant height in mulched plants was possibly due to better availability of soil moisture and optimum soil temperature provided by the mulches. Changes in the plant height of chilli have been observed by using different mulches and plastic mulch increased the plant height than other mulches (Shinde *et al*., 1999).

Table 6: Effect of different mulching materials on plant height (cm)

	Weeks after transplanting		
Treatment	2	4	6
Plastic mulch	42.17	81.3	93.5
Dry grasses	39.33	63.4	74.6
Rice husk	32.67	64.5	77.6
Saw dust	36.50	72.6	86.8
Control	31.00	55.6	70.0
$LSD_{0.05}$	6.184	11.24	12.80

Table 7 showed the effect of different mulching materials on the yield of tomato. Observed data showed that there was significant difference ($p<0.05$) in the yield of tomato. Plastic mulch had the highest tomato yield (5.08kg/plant)>Rice husk (4.50 kg/plant) >dry grasses (4.45 kg/plant)> Saw dust (4.77 kg/plant); the least yield was recorded in the control (3.10 kg/plant).

Table 7: Effect of different mulching materials on tomato yield

Treatment	Yield (kg/plant)
Plastic mulch	5.08
Dry grasses	4.45
Rice husk	4.50
Saw dust	4.77
Control	3.10
$LSD_{0.05}$	0.97

CONCLUSIONS AND RECOMMENDATION

This study showed that tomato (padma 108 f1 hybrid east west seeds) responded to mulching. Soil pH, organic carbon, available phosphorus, and exchangeable cations (Ca, K, Mg, and Na) increased as a result of increase in organic matter associated with the application of mulches. These attributes led to enhanced growth and yield of tomato. The advantages derived from mulching were reflected in plant height, number of leaves and number of branches. Among the mulching materials tested, black plastic mulch favored growth parameters and yield of tomato. The result of this study indicated that black plastic mulch displayed superiority over the other mulch materials used in this study. Therefore, application of black plastic mulch using padma 108 f1 hybrid east west seeds is recommended for tomato producers in the study area.

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Effect of Different Live Mulches on Soil Physicochemical Properties and Yield of Okra in Nnamdi Azikiwe University, Awka, Nigeria

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K E Y W O R D S

Soil properties,
Live Mulches,
Calopogonium mucunoides,
wild ground nut,
Pumpkin,
Melon;
Cowpea

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A B S T R A C T

This experiment was carried out in the Department of Soil Science and Land Resources Management Research Farm, Faculty of Agriculture, Nnamdi Azikiwe University Awka, to determine the effect of different live mulches on physico-chemical properties of soil and yield of okra. Treatments include cowpea + Okra (CO), Melon + Okra (MO), pumpkin + Okra (PO), Wild ground nut + Okra (WgO) and the control (O). The experiment was laid in a Randomized Complete Block Design (RCBD). Plant height, number of leaf and leaf area index were collected at 4, 6 and 8 weeks after planting. Soil samples were collected, air dried, sieved and analyzed for physical and chemical properties using outlined standard and scientific methods in the laboratory. Data collected from field and laboratory was subjected to Analysis of Variance while significant means were separated using Fishers Least Significant Difference at 5%. Results indicated that live mulches conserved soil moisture and reduced bulk density of the soil while increasing soil pH, Organic matter, nitrogen, phosphorus and most basic cations (Ca, Mg, K, Na) tested. It also improved growth and development of the crop (okra). Among the live mulches tested, Calopogonium mucunoides(wild ground nut) had better capability of improving soil properties and the growth of okra when compared to other live mulches.

INTRODUCTION

Mulch is either organic or inorganic material that is spread on the surface of the soil to reduce moisture and nutrient losses due to evaporation. Live mulches are cover crops that are sown either before or with a main crop and are maintained as living ground cover throughout the growing season (Hartwig and Ammon, 2002). Application of mulch on the soil prevents surface evaporation thereby, conserving water (Patil *et al*., 2013). The word mulch was derived from the German word 'molsch' meaning 'easy to decay' and mulches have been used for vegetable production (Lightfoot, 1994). Mulches have the potential of minimizing runoff, improving the infiltration capacity of the soil and restraining the amount of weed through shading (Rathore *et al*., 1998). According to Tanavud *et al*. (2001) mulching materials are useful in the protection of soil from erosion by both water and wind, reduce soil compaction which could adversely affect the growth and development of crops. Live mulch helps in providing good soil conditions for the main crop to thrive. Although, soil quality is affected by the type of live mulch used. Food and feed living mulches improve soil organic carbon (OC), total nitrogen (TN), available phosphorous (AP), microbial biomass and soil bacterial structure and function better in legume live mulches than non-legume live mulches (Duda *et al*. (2003). Live mulches also improve soil moisture, infiltration, soil bulk density, temperature and erosion when compared to non-living mulch plots (DeVetter *et al*. (2015)

Okra (*Abelmoschus esculentus*, L) is known in many English-speaking countries as lady's finger, bhindi in India, okro plant, ochro. Okoro, gombo, kopi arab, kacangbendi and bhindi in Southeast Asia (Ndunguru, and Rajabu, 2004). Okra is a nutritious vegetable which is widely cultivated throughout the year in the tropics. It plays an important role in meeting the demand of scanty vegetables in the market (Ahmed *et al*., 1995). The aim of this study was to determine the effect of different live mulche on the physicochemical properties of soil and the yield of okra.

MATERIALS AND METHODS

Description of Experimental Area

This study was conducted at the Department of Soil Science and Land Resources Management Research Farm, Faculty of Agriculture, Nnamdi Azikiwe University, Awka, Anambra State. The latitude of Awka is 6.210528 and longitude is 7.072277. Awka is in the tropical rainforest zone of Nigeria and experiences two (2) distinct seasons of heavy rainfall between April and July accompanied by dry season November- March marked by a harmattan wind (Wikipedia). The average annual temperature is 26.8 ^{o}C and rainfall around 1589mm per year (https:en.climate-data.org).

Experimental Design

The experiment was laid out in Randomized Complete Block Design (RCBD), having 5 treatments with 5 replications. The treatments include Cowpea and okra (CO); Melon and okra (MO); Pumpkin and okra (PO); wild ground nut and okra (WgO); Control (sole okra) (O)

Field Operations and Land Preparation

A field size of 16m by 22m was marked out using measuring tape, rope, and peg. The Land was cleared, ploughed, harrowed, and ridged at 4m x 2m. The blocks were 1m apart. Poultry manure was applied on each ridge at the rate of 10 t/ha and was left to cure for one week before planting. The test crop was okra and was soaked overnight and drained before planting to speed up the germination. Seeds were sown at the recommended spacing of 0.6m by 0.9m at two seeds per hole which was later thinned down to one plant/stand. Weeding was done manually at week four using hoe to reduce weed competition

Materials and Sources

Okra seeds (Cajun delight - Dwarf green pod) was sourced from Agricultural Development programme in Awka. Melon, cowpea, and pumpkin seeds were sourced from seed vendors in Awka while wild ground nut was s sourced from the Faculty of Agriculture Unizik, Awka.

Soil Sampling

Soil samples were randomly collected before planting from within the experimental field at a depth of 0-15cm using a soil auger. Soil samples were collected after harvest from stipulated points and tagged separately. Core samplers were used to collect undisturbed soil samples at the experimental field. Both samples were taken to the laboratory for the analysis. Soil samples for analysis were collected before and after the experiment.

Laboratory Analysis

The following parameters were analyzed for: Particle Size Distributions was determined using Bouyoucus hydrometer method as described by Bouyoucus (1962). Bulk density was determined using core method (Blake and Hartge, 1986). Soil pH was determined in H_2O and KCL using glass electrode pH meter at a soil liquid ratio of 1:2.5 as modified by Udo *et al*. (2009). Soil Organic Carbon was determined by Walkley *and* Black wet oxidation method as modified by (Nelson and Sommers, 1996). Total Nitrogen was determined by Kjeldhal digestion method (Bremmer and Mulvaney (1996). Available Phosphorus was determined by Bray 2 method as described by Bray and Kurtz (1945). Exchangeable bases were extracted using 1.0N ammonium acetate (NH_4OA_c) (Black and Hartge, 1986). K and Na^+ were determined using flame photometer while Ca and Mg were determined using EDTA titration method. Exchangeable acidity was determined using 1.0N KCl solution and 1.0N sodium fluoride (NaF) titrated with 0.05M HCl. The effective cation exchange capacity (ECEC) was calculated as the sum of exchangeable bases (Ca, Mg, K and Na) and exchangeable acidity (Al^{3+} and H^+).

Data Collection on Okra

The data collected are growth and yield of the okra, plant height, number of pods, number of leaves and leaf area index.

Statistical Analysis

Data collected was subjected to Analysis of variance (ANOVA) for Randomized Complete Block Design (RCBD) using Genstat Release 12.1, 3rdedition and significant means were separated using the Fishers least significant difference (LSD) at 0.05 probability level.

RESULTS AND DISCUSSION

Table 1 showed the physicochemical properties of the initial soil sample. The textural class of the experimental plot is Sandy loam, strongly acidic and low in moisture content.

Table 1: Physicochemical properties of the initial soil sample (0-15 cm)

Soil properties	Average values
Sand (%)	70.30
Silt (%)	15.20
Clay (%)	14.50
Soil texture loam	Sandy
Moisture content (%)	14.10
Bulk density (gcm-3)	1.44
pH	5.3
Available phosphorus (mg/kg)	15.8
Nitrogen (%)	0.108
Organic Carbon (%)	1.21
Ca2+ (cmol/kg)	4.30
Mg2+ (cmol/kg)	1.6
K+ (cmol/kg)	0.151
Na+(cmol/kg)	0.105
Al3+ (cmol/kg)	0.52
H+ (cmol/kg)	1.06
Exchangeable acidity	1.58
ECEC (cmol/kg)	7.74

Source: field data

Effect of different live mulch on the physical properties of the soil

Table 2 showed the effects of different live mulches on soil physical properties. The results obtained showed that there was no significant difference between the treatments and soil texture. Bulk density between the treatments differed significantly and was in this order: O (1.48) > MO (1.43) > PO (1.39) > CO (1.36) > WgO (1.32), for soil moisture content, there was a significant difference which was in the order: WgO (26.68) > CO (18.22) > MO (17.5) > PO (16.28) > O (12.9). An increase in moisture content agrees with Nurudeen *et al*. (2022) who observed an increase in the moisture content when cowpea was used as a live much compared to control. Sharma *et al*. (2010), Wiggan *et al*. (2012) and De Vetter *et al*., (2015) also observed that live mulches improved moisture content, infiltration rate and bulk density. Nurudeen *et al.* (2022) recorded a decrease in the bulk density of cowpea live mulch ($p < 0.05$) when compared to the control.

Table 2. Effects of different Live Mulch on Soil Physical Properties

Treatment	Sand %	Silt %	Clay %	Tex	MC %	BD g/m^3
Cowpea + okra (CO)	70.5	15.1	14.4	SL	18.22	1.36
Wild ground nut + okra (WgO)	70.3	15.2	14.3	SL	26.68	1.32
Pumkin + okra (PO)	70.7	15.0	14.3	SL	16.28	1.39
Melon + okra (MO)	70.5	15.1	14.4	SL	17.5	1.43
Control (sole okra) (O)	70.3	15.2	14.5	SL	12.9	1.48
Mean	70.46	15.12	14.42	SL	17.52	1.39
$LSD^{(0.05)}$	NS	NS	NS		0.38	0.02

Note: tex = texture, Mc = moisture content, BD = Bulk density, LSD= least significant difference

Effects of different live mulches on soil chemical properties

Table 3 showed the effects of live mulch on Soil chemical properties. Exchangeable bases were observed to significantly vary at ($p>0.05$). Calcium was highest in WgO (6.44) and lowest in the control (3.8), magnesium was in this order: WgO (3.62) > CO (3.04) > MO (2.80) > PO (2.38). Similarly, this study has shown that all values of the live mulch on exchangeable acidity are higher than the control plot. This corroborates with the findings of Awopegba *et al*. (2017) who observed a significant increase in the exchangeable bases in the soils covered with herbaceous mulch treatment of *Calopoganum* and Moringa, he recorded an increase in Ca level in plots with moringa (3.90 cmol/kg) and Calopoganum (3.20 cmol/kg) When compared to the control, also an increase in Mg level with *Calopoganum* (1.40cmol/kg) was recorded. Again, *Calopogonum* and moringa increased potassium level significantly (1.62 and 1.93 cmol/kg) when compared to the control. There was a significant difference in sodium as influenced by the live mulches. This finding agreed with the findings of Awodun *et al.* (2007) that legumes are sources of utilizable N, P, K, Ca, Mg and organic matter. There was a significant difference in all the treatments at (p>0.05). This study showed that for $H^{+,}$ control was the highest (1.19) while wild ground nut was the lowest (0.52). For $Al^{3+,}$ control has the highest value (0.77) while wild groundnut was the lowest (0.32).

Results obtained showed that there is a significance difference between the treatments at (p>0.05). The ECEC was in the order: WgO (11.56) > CO (11.09) > MO (10.02) > PO (9.51). ECEC was higher in mulch plots than in the control plot.

The plot with wild ground nut had the highest pH (6.12) and lowest value on the control plot, this agrees with Awopegba *et al.* (2017) that recorded a significant increase in pH on the plots with live mulch when compared to control. The increase in the soil pH might be because of chopped herbaceous mulch which tends to improve the soil exchangeable bases while reducing exchangeable acidity thereby reducing soil acidity; this also was experienced by Egbe *et al*. (2012).Organic carbon showed a significant difference between treatments at (p>0.05), WgO was highest (1.66) while the lowest was control (1.06). Organic carbon was in the order: WgO (1.66) > CO (1.56) > PO (1.51) > MO (1.44) > control (1.06). This is evidence that mulch materials used increased the organic carbon content of the soil when compared with the control; this is in line with Awopegba *et al*. (2017) who recorded a significant increase in the soil organic carbon with *Calopoganum mucunoides* (1.99g/kg) recording the highest soil organic carbon when compared to other mulch materials and the control. This study report corroborates with the findings of Tejeday *et al*. (2007) who observed that the application of leguminous residues had a positive effect on soil physical, chemical and biological properties. There was a significant difference among the treatments at (p>0.005) as far as nitrogen is concerned. CAO had the highest value of nitrogen (0.154%) while the lowest was observed in control (0.092%). Awopegba *et al*. (2017) had a similar result though Gliricidia sepium had the highest N ((7.18%)) when compared to calopogonum (5.10%).

Table 3. Effects of live mulch on soil chemical properties

	Soil chemical parameters										
Treatment	**pH**	**OC %**	**TN %**	**Av.P mg/kg**	**Ca2+**	**Mg2+ cmol/ kg**	**K+ cmol/ kg**	**Na+ cmol/ kg**	**H+ cmol/ kg**	**Al3+ cmol/ kg**	**ECEC cmol/ kg**
Cowpea + okra	4.84	1.56	0.138	18.6	5.8	3.04	0.294	0.255	1.14	0.56	11.09
Wild ground nut + okra	6.12	1.66	0.154	20.96	6.44	3.62	0.355	0.31	0.52	0.32	11.56
Pumkin + okra	5.2	1.51	0.131	18.58	5.08	2.38	0.246	0.202	1.08	0.51	9.51
Melon + okra	5.74	1.44	0.124	20.18	5.48	2.8	0.279	0.23	0.81	0.42	10.02
Control (sole okra)	4.12	1.06	0.092	14.58	3.8	0.96	0.095	0.075	1.19	0.77	6.89
Mean	5.2	1.44	0.128	18.58	5.32	2.6	0.254	0.214	0.95	0.52	9.81
LSD (0.05)	0.19	0.05	0.005	0.62	0.12	0.14	0.014	0.013	0.05	0.02	0.24

ECEC = Effective Cation Exchange Capacity; BS = base saturation; LSD= least significant difference; Av. P= available phosphorous; TN= total nitrogen; OC = organic carbon

Effects of live mulch on plant parameters

The plant height at four weeks after planting, showed a significant difference such that WgO (31.81a) and PO (31.88a) varied significantly from Control (24.79b) which was statistically different from MO (30.47ab) which was statistically the same with CO (30.09ab). At six weeks and eight weeks after planting there was no significant difference among the different treatments and the control. Number of leaves as well as the leaf area index were not significantly different at the 4th, 6th and 8th WAP.

Table 4a: Effects of different live mulches on plant height

Treatment	**Plant height 4 WAP**	**Plant height 6 WAP**	**Plant height 8 WAP**
Cowpea + okra (CO)	30.09ab	78.8a	111.7a
Wild ground nut + okra (WgO)	31.81a	77.4a	116.0a
Pumkin + okra (PO)	31.88a	72.8a	112.1a
Melon + okra (MO)	30.47ab	72.8a	107.9a
Control (sole okra)	24.79b	74.0a	106.4a
Mean	**29.81**	**75.1**	**110.8**
LSD (0.05)	**NS**	**NS**	**NS**

WAP: weeks after planting, LSD= least significant difference, NS= not significant

For the number of flowers at 4WAP, there was a significant difference in this order: PO (5a) = MO (5a) > CO (4ab) = WgO (4ab) = Control (4ab). At six weeks, the pods have developed and so instead of numbering the leaves, the pods are numbered which varied in this order: PO (10a) > CaO (9ab) = MO (9ab) > (8b) = Control (7b). At the 8th week, there was no significant difference.

Table 4b: Effects of Different Live Mulches on number of flowers and number of Pods

Treatment	Number of flowers 4 WAP	Number of Pods 6 WAP	Number of Pods 8 WAP
Cowpea + okra (CO)	4ab	8b	13a
Wild ground nut + okra (WgO)	4ab	9ab	12a
Pumkin + okra (PO)	5a	10a	13a
Melon + okra (MO)	5a	9ab	13a
Control (sole okra)	4ab	7b	12a
Mean	4	9	13
LSD (0.05)	NS	1.52	NS

WAP= Weeks after planting, LSD= least significant difference, NS= not significant

CONCLUSION

From the results, it could be observed that mulch materials had significant impacts on organic matter content, nitrogen, exchangeable bases, and pH. The acidity of the soil was reduced with the live mulch from Al^{3+} (0.77 cmol/kg) and H^{+}(1.19 cmol/kg) on the control plot to Al^{3+}(0.32 cmol/kg) and H^{+} (0.52 cmol/kg) WgO which was used as a live mulch, and this gave rise to the increase on pH of the soil. In comparison with the different mulch materials used, there was a steady flow or pattern with which the different mulch materials affected or influenced the soil physical and chemical properties, *Calopoganum Mucunoides* and okra plot differed significantly from other mulch materials, hence it can be concluded that wild ground nut is a better live mulch when compared to cowpea, melon and pumpkin. It would be recommended that for proper maintenance and sustainability of soil fertility, *Calopogonium* should be used as live mulch in the study area.

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SUB-THEME 3

ROLE OF FOREST ECOSYSTEM AND NATURAL RESOURCES MANAGEMENT IN CLIMATE CHANGE ADAPTATION AND MITIGATION

Multipurpose Tree Species OF Akwa Ibom State and their Non-Timber Forest Products

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K E Y W O R D S

NTFPs,
Multipurpose trees,
Environmental services,
Agroforestry systems

A B S T R A C T

Multipurpose tree species are trees that have the ability to provide numerous products and perform diverse functions in farming or forestry. They play crucial role in the livelihood of the people of Akwa Ibom State, Nigeria. . Multipurpose trees are of significant importance as they are major source of Non-timber Forest Product. They produce environmental services such as soil conservation, nitrogen-fixation, Windbreaks, carbon sequestration, soil reclamation, erosion control and beautification. Therefore, integration of multipurpose tree species into an agricultural farmland will give the people economic stability and also control forest destruction. These tree species that provide NTFPs, need special attention and should be incorporated into suitable agroforestry systems. This review article discusses some indigenous multipurpose tree species of Akwa Ibom State that can be incorporated into suitable agroforestry systems.

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INTRODUCTION

The increasing population of humans and animals has been one of the most distressing factors for the depletion of forest in Akwa Ibom State. Forests in the tropical region are disappearing at an alarming rate and man is a silent spectator of the denudation of this natural resource which has been described as a “power house of evolution” and major source of “wild medicine” (Saxena *et al.,* 2001). The rate of forest destruction in the state is extremely high as a result of various developmental projects carried out by the government. This contributes immensely to the high rate of deforestation in Nigeria which according to Njungbwen and Mbakwe (2013) is one of the highest in the world. In Akwa Ibom State, developmental projects such as housing estates, airport, schools, hotels, roads, library and many more have led to the destruction of various forest lands.

The demand for forest products by man especially in Nigeria increased greatly during the colonial era. From then on, more and more natural forests were exploited. This resulted in destruction of forest products such as trees and other related products. This is what is called deforestation, a situation whereby forest plants and animals are destroyed, leading to their extinction (King and Udo, 2001). The impacts of deforestation manifested in soil degradation, increased erosion, air, land and water pollution, climate change (Udo, 2015).

In recent times, several attempts to rehabilitate the degraded forests and to bring more areas under forest cover by government officials, NGOs and individuals have been made. As the government of the day in making ultimate objective of bringing the degraded forests of the state under forested areas, there is a strong need to restore the forest through cultivation of suitable multipurpose tree species which will not only enhance the environmental services but will also provide Non Timber Forest Products to the people living within the forest areas. Multipurpose tree species should be incorporated into agro-ecosystem particularly agroforestry system.

Government agencies in forestry sub-sector should raise and distribute seedlings or seeds of these multipurpose trees to farmers for planting on their farms and gardens. Incorporation of multipurpose tree species in agroforestry system would protect the remaining wild population.

Some indigenous multipurpose tree species in Akwa Ibom State

***Dialium guineense* Wild (Velvet Tamarind)**

Dialium guineense, the velvet tamarind, is a tall, tropical, fruit bearing tree in the flowering plant family Febaceae. It has small, typically grape-sized, edible fruit with brown, hard, inedible shells. It is a fruit of a native West African tree cultivated not only for its fruits but as a source of timber and fuel. In Akwa Ibom State, tamarind is a very popular fruit snack, particularly among children, who peel the black velvet case to reveal an orange pulp that is eaten raw. *Dialium guineense* grows in dense forests in Africa, it has a straight, greyish and smooth stem.

Dialium guineense Wild is multipurpose tree that has various utility benefits. The fruit is popularly used as food. The fruit contains very hard seed, the pulp has a sweet-sour astringent flavour similar to baobab, but sweeter. It can be eaten raw when dry by man and animal (Matsuda, 2006). The pulp when peeled is also eaten raw in south-east Nigeria because of its refreshing properties and pleasant scorching taste (Ubbaonu *et al.,* 2003). It could also be used as flavour in snacks and non-alcoholic beverages (Effiong *et al*., 2009).

The tree is used to make charcoal and the bank is used as chewing stick (indigenous tooth brush) among Nigerian populace (Akinpelu *et al.,* 2011). The bark, it is chewed for oral hygiene and stomach ache among the Esan people of Edo State (Besong *et al.,* 2016). It is also used to improve lactation and in checking genital infection in South East Nigeria (Besong *et al.,* 2016). In Akwa Ibom State, *Dialium guineense* is well known, valued and widely utilized. It serves different purposes of the local nature in the state. The tree is used for soil conservation, staking of yam, and the leaves are used as manure. It is well recognized by indigenous knowledge, as an agroforestry nitrogen fixing species. It is on the nutrient retention qualities of the tree that the farmers in the state retained, planted (scattered) them in traditional cropping system.

Economic Importance

1. *Dialium* is unique among plants. it is used as food.
2. It is a medicinal plant – use for oral hygiene and genital infection treatment.
3. Use as vitamin supplements
4. It has good timber quality used for construction
5. Wood is good for fuelwood and charcoals production

Environmental Services

1. It is used for soil conservation
2. The tree is used as natural fallow species for fertility restoration
3. The leaves are used as farmyard manure.

***Pentaclethra macrophylla* Benth. (Oil bean tree)**

Pentaclethra macrophylla also known as the African oil bean tree is a large size tree with long bipinnate compound leaves that is endemic to West Africa. It belongs to the family Fabaceae (Mimosoidae) and is the sole member of the genus occurring naturally in the humid lowlands of West Africa. It is evergreen tree growing to 30 m at a fast rate. *Pentaclethra macrophylla* is common in primary forest and secondary forest and coastal savannah, often in the vicinity of creeks and rivers. It is planted or retained along the edges of home gardens and farms mainly for its seed. In Nigeria, the oil bean tree is found in the southern rain forest zone. *Pentaclethra macrophylla* is one of the indigenous tree species in Akwa Ibom State. It is an important multipurpose tree for the people of the state. Seeds of oil bean tree have high fat content and are eaten along or used as food supplement. The seeds are slightly fermented and cut into small shreds to make a very nutritious snack called "Ukana" which is very popular among the Ibibios of Southern Nigeria. Women and children are into the collection and sale of oil bean seeds. Virtually all parts of this plant, including the seeds, leaves, stems, barks, trunks and roots are very useful for traditional and conventional medicinal health care.

Economic Importance

1. It is found very useful as a food supplement
2. It is potential source of income
3. The wood serves as firewood and charcoals
4. It is very useful for medicinal health care

Environmental Services

1. The wood and leaves serve as manure
2. It is good in soil conservation
3. It is a good source of shade and ornamental plant
4. It is well known nitrogen-fixing tree

***Gambeya albidum* G. Don *(*Africa star apple)**

Gambeya albidum is a climax tree species of tropical rainforest that belongs to the family Sapotaceae (Olaluwa *et al.,* 2012; Wole, 2013) which has up to 800 species and make up almost half of the order (Ehiagbonare *et al.,* 2008). African star apple, an indigenous plant is an edible tropical fruit known by various tribal names in Nigeria as agbalumo (Yoruba), Udara (Ibo, Efik and Ibibio), ehya (Igala) and Agwalumo (Hausa) (Dandare *et al*., 2017). The fleshy edible pulp is consumed by people (CENRAD, 1999) and for the purpose of stopping irritation, loss of appetite and salivation. Fruiting season of the plant is usually in the months of December to April during which it is found both in rural and urban cities (Amusa *et al.,* 2003). Studies have shown the fruit to be an excellent source of vitamins, iron, flavours to diet and raw materials to some manufacturing industries (Okafor and Fernandes, 1987; Bada, 1997; Umelo, 1997; Adisa, 2000).

It helps in prevention of mouth gum diseases, treatment of toothache as well as sore throat (Onyeakagbu, 2019). The diverse nutritional content of the fruit is very good for the digestive system and nutrient consumption of the pregnant mother and fetus (Agustin, 2018). The fruit is rich in fibre and contains compounds that are hypoglycemic that serve to lower blood sugar levels (Agustin, 2018). *Gambeya albidum* has been noted to be of great medicinal, nutritional (Adisa, 2000); Onyekwelu and Stimm, 2011) and economically values (Oboh *et al.,* 2009).

Economic Importance

1. The fruit serve as raw materials to some manufacturing industries
2. It is used in the preparation of medicine for the treatment of disease
3. The fruits are consumed because of its sweetness and nutrition value
4. The fruits are widely eaten by people
5. Its fruit milky juice contains a high content of vitamin C
6. The oil is extracted and used in making soap and other products.
7. It can also be used in the preparation of wine, spirits and soft drinks, jam and jellies (Umelo, 1997).

Environmental Services

1. It is a good species for carbon sequestration
2. The trees are used for windbreak
3. It is a good source for shade and ornamental plant
4. It is well suited for degraded lands, it thrives on all kinds of soil
5. It is recommended for reclamation of wasteland.

***Treculia africana* Decne (African breadfruit)**

Treculia africana is a large evergreen tropical tree belonging to the family of Moraceae. Its distribution extends from latitude 13^{o} N of Angola and down to Saotome Island, and within the approximate latitude range of 15^{o} N to 20^{o} N (Keay, 1989; WAC, 2005). It is widely distributed in the following towns of Nigeria mostly in Oyo, Ogun, Anambra, Cross River, Delta and Imo States (Keay, 1989). It is specially called "Adiang" by the Ibibio people of the South South Nigeria.

Treculia africana is a source of food to many families in Akwa Ibom State. The seed is variously cooked as sole porridge or mixed with other food stuff such as Sorghum (Onweluzo and Nnamuchi, 2009), or roasted and sold with palm kernel (*Elaeis guineensis*) as road side snack. The flour is high potential usage for pastries (Onyekwelu and Fayose, 2007). The seeds are highly nutritious and constitute a cheap source of vitamins, mineral, proteins, carbohydrates and fats (Okafor and Okolo, 1974).

Proximate analysis shows that the seed contains 17-23% crude protein, 11% crude fat and other essential vitamins and minerals (Akubor *et al.,* 2000). The seed kernel is used in preparing pudding as a thickener in traditional soups and in the manufacturing food products such as flour for bread, beverages and weaning of children (Onyekwelu and Fayose, 2007). African breadfruit is an important natural resource for the poor, contributing significantly to their income and dietary intake, especially under poor heart conditions (Ogbonnia *et al.,* 2008), and as animal food (Ejidike and Ajuleye, 2007). It is also useful in the ethno-medical management of diabetes mellitus. The tree crop is widely cultivated in the Southern parts of Nigeria, where it serves as low-cost meal substitute for poor families in some communities (Ugwu *et al.,* 2011).

Economic Importance

1. *Treculia africana* is a source of food. The seed is cooked as sole porridge, the seeds are highly nutritious, source of vitamins, mienrals, proteins, carbohydrates and fats.
2. It is a good source of ethno-medical plant. It is used in treatment of diabetes mellitus.
3. It is a source of food to wild animals such as monkeys and chimpanzees
4. The wood as long been used for charcoal and fuel-wood

Environmental Services

1. Breadfruit trees are used for soil conservation projects and programmes.
2. Leaves are great source of manure. The leaf fall is a good source of mulch
3. Treculia trees help in combating the many inter-related environmental crises that threaten the very future of life on earth.
4. They are used as shade trees
5. The trees tolerate wide range of climatic conditions
6. It has been recommended as a promising species for used in home gardens, as for intercropping systems in agroforestry.

***Irvingia gabonensis* Baill (Bush mango)**

Irvingia gabonensis is a tree native to West Africa. It is sometimes known by the common names wild mango, African mango or bush mango. They bear edible mango-like fruits and are especially valued for their fat and protein rich nuts. It is evergreen dense rain-forest tree, it grows straight, up to a height of 25 m and 2 m in diameter (Omokhua *et al.,* 2010). The fruit has sweet edible fibrous pulp which is rich in vitamin C. The most important part of Irvingia to the people of Akwa Ibom State is its nutritious seeds. It is known as mbukpabuyo by the Ibibio and Efik people. According to Ladipo *et al*. (1996), the Irvingia genus is made up of 7 species. The pulp of *Irvingia gabonensis* is sweet and juicy. This species can grow in a farmland, semi deciduous forest, and canopied bush or gallery forests. The seeds are primarily used for soup making in the state and many parts of Nigeria. Many rural people are involved in collection and marketing of the species edible pulp in many parts of the country where the species are in abundance. The species is one of the most useful forest trees in Akwa Ibom State as it forms an integral part in the livelihood of the rural communities. The trees improve air quality, windbreak and play important role in soil protection and formation.

Economic Importance

1. *Irvingia gabonensis* is used primarily for food.
2. The nuts provide fat and protein, while the pulp is rich in Vitamin C.
3. It is a good source of income generation to the rural communities
4. The wood is strong and durable, used in construction. It is used as fuel.
5. It is used as medicine. The seeds lower cholesterol because of their high fiber content. It is also used in treatment of diabetes and bacteria (Ngondi *et al.,* 2005; Kuete *et al*., 2007 and Sulaiman *et al.,* 2015).
6. Fruits and seeds can serve as fodder fed to farmland livestock.

Environmental Services

1. The tree provides shade, useful in intercropping systems, where intense direct heat can damage crops.
2. It can be planted for preventing and controlling erosion
3. Trees are planted for Ornamental and beautification purposes.

CONCLUSION

Multipurpose tree species provide varieties of products including forest vegetables, fruits, fodder and products for medicinal purposes. These trees are used for food purposes all over the world. The multipurpose tree species provide nutritional security to rural and tribal population. These trees have potential to provide important community needs for improved rural livelihood. They also contribute to food security, create employment and generate additional income to farm household. Multipurpose tree species also helps in generating income for marginal farmers and provide environmental services including soil conservation, restoration and rehabilitation. The awareness of integrating trees/shrubs within traditional cropping system will help in ensuring multipurpose trees are adequately incorporated into agroforestry systems. These systems can be an important avenue in which trees/shrubs with multiple benefits can be same piece of land. This will not only boost agricultural production but will also provide food securities to the increasing population.

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Conservation Strategies of Forest Resources: A Path to Sustainability

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K E Y W O R D S

Forest resources,
Conservation,
Strategy,
Sustainable use

A B S T R A C T

Forests around the world have been and continue to be threatened by uncontrolled degradation and conversion to other types of land uses, influenced by increasing human needs such as; agricultural expansion and environmentally harmful mismanagement. The current situation necessitates immediate and consistent action to conserve and sustain forest resources so as to maintain ecological balance for supporting life, preserve different kinds of species (biodiversity), make the resources available for present and future generations and ensure the survival of human race. To safeguard this, conservation practices around the globe are shifting away from the indigenous conservation method, emphasizing on the management of natural resources in a manner that ensures higher flow to every stakeholders, particularly rural community members. As a result, conservation strategies that can aid in the development of goals and action plans for the sustainable use of forest resources are been emphasized on, typically by seeking broad-scale consensus through comprehensive consultations. This article therefore reviews the need for conservation of forest resources and conservation strategies in Nigeria.

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INTRODUCTION

Forest resources include timber and other products that can be extracted privately while also providing widely disseminated benefits in terms of climate and atmospheric conditions that are shared by all. Ucar *et al.* (2020) confirmed that the forest, a tangible symbol of the environment, contributes significantly to human health and environmental quality by providing ecological services (energy savings, improved air quality, aesthetics, health benefits, wildlife habitats, and recreation opportunities), economic (productivity, quality, and quantity of forest resources), and social (employment and health safety). However, despite all of these numerous benefits, destructive anthropogenic activities continue unabated.

Conservation has been defined by many researchers, including Farm Bill (2014), Hobfoll *et al.* (2017), and Lichtenfeld *et al*. (2019), as the appropriate management of natural resources to avoid its exploitation, damage, or degradation. According to Bisong (2001), conservation practices around the globe are shifting away from the local conservation method, emphasizing the management of forest resources in a manner that ensures higher flow to every stakeholder, particularly rural community members. Bamberger (2006) reported that many African countries have shifted from "top-down" (expert-led) approaches and to more inclusive "bottom-up" (community-led) methods. The shift in emphasis is informed by the fact that local communities are inextricably linked to their cultural resources, whether used as a source of food, medicine, fuel, or for maintaining ecological balance; thus, local cooperation, participation, and management are critical to achieving both short-term development results and long-term sustainability (Bisong, 2001). Thus, sustainable natural resource management necessitates further comprehensive measures that involves empowering rural community group, technological abilities, and garnering support for sustainable resource utilization from larger community groups (Food and Agricultural Organization, FAO, 2005).

As a result, conservation strategies that can aid in the development of goals and action plans for the sustainable use of forest resources are required, typically by seeking broad-scale consensus through comprehensive consultations. Conservation strategies, as opposed to many traditional planning exercises that are uni-sectoral or focus solely on land-use planning or economic planning, can include environmental, social, and economic objectives. Thus, conservation strategies must be viewed as a process as well as a product. Because the method of development generates buy-in from the partners who will put the strategy elements into action, the method of development is almost as important as the strategy's contents.

Need for Conservation of Forest Resources

According to the United Nations (1992), forests around the world have been and continued to be affected by unregulated degeneration as well as transformation to other land use type, which is impacted by expanding public demands; agricultural intensification; as well as environmentally hazardous mishandling, such as absence of appropriate woodland-fire regulation and anti-poaching approaches, unsustainable timber harvesting, overgrazing and uncontrolled grazing, detrimental consequences of air contaminants, and economization. The current situation necessitates immediate and consistent action to conserve and sustain forest resources so as to:

• **Maintain ecological balance for supporting life:** Forests play an important role in preventing global warming and building sustainable societies. Carbon dioxide’s direct effects on vegetation contribute to global warming. Through the pores called stomata in their leaves, trees and plants take in carbon dioxide from the atmosphere that they use for photosynthesis. They then give off water through the stomata in a process called evapo-transpiration which cools the plant just as perspiration cools human beings. Forests serve a variety of functions, including land conservation, securing water sources, climate change control, and the creation of natural environments necessary for human survival.

• **Preserve different kinds of species (biodiversity):** Forests house a large portion of the Earth's ecosystem, species, and genetic diversity. Many forest tree species have high genetic diversity, and its loss, while often unnoticed, may have far-reaching consequences. Thus, the need to conserve forest resources cannot be overemphasized.

• **Make the resources available for present and future generations:** Conservation of forest resources addresses the principle of intergenerational equity and sustainability, which is concerned with ensuring that today's resource use does not jeopardize the availability of resources for future generations.

• **Ensure survival of human race:** Forest resources support the livelihoods. These resources provide food, fuel, medicine, shelter, and other necessities. According to Millar and Stephenson (2015), humans rely on healthy forests for energy, building materials, food, and a variety of ecological and environmental services such as carbon storage, biodiversity, and climate control.

The World Conservation Strategy

World Conservation Strategy (1980) stated that until recently, many conservationists took an "anti-development" stance, arguing that resources, wilderness lands, and habitat should be protected from all human use. This stance made conservation appear to be a very unappealing option for many developing countries that rely on resource use to generate economic growth, as complete protection would effectively preclude large areas from future use. Furthermore, many countries could not afford to establish protected space programs, as well as to clear settlement from designated areas and establish protection and management for them.

As the global environmental crisis became more pronounced in the 1970s, the tension between preservation and development grew, and it became clear that the international community needed to find a way to reconcile environmental protection goals with economic development goals. A solution appeared to be found in an approach that incorporated both preservation and development into a broader conservation framework. The World Conservation Strategy (WCS) was published in 1980 with the intention of bringing about such reconciliation.

The World Conservation Society (WCS) aimed to provide a framework and policy guidance for resource conservation. The WCS was founded by the International Union for Conservation of Nature (IUCN), the United Nations Environment Program (UNEP), and the World Wildlife Fund (WWF). The WCS is aimed at government policymakers, conservationists, resource managers, and development practitioners, including NGOs (non-governmental organizations), donors, private sector, as well as labour organizations. As a document, it provides information while also establishing clear action priorities. To address these priorities, the WCS have served as the foundation for action at multiple scales.

It represented a significant departure from tradition, by redefining conservation to include human use and development activities explicitly: "the management of human use of the biosphere so that it may yield the greatest sustainable benefit to present generations while maintaining its potential to meet the needs of and aspirations of future generations" (World Conservation Strategy, 1980). Resource conservation, then, became a development strategy, rather than a barrier to development. At the same time, it is recognized that protection of specific species and ecosystems may also be critical to any overall conservation program.

Thus the creation of protected spaces becomes one of the strategies available to those who would implement an overall conservation strategy.

The WCS identifies three critical objectives for conservation:

- to maintain essential ecological processes and life support systems through rational planning, allocation, and management of resources;

- to preserve genetic diversity through the collection and banking of genetic material, and ecosystem protection; and

- to ensure the sustainable utilization of ecosystems, through knowledge and understanding of the productive capacities, and measures to ensure that utilization does not exceed those capacities

The strategy provided a comprehensive discussion of major issues relating to these objectives and established conservation targets. It also identified key problem areas with respect to achieving each of the three objectives.

National Conservation Strategies

The WCS challenged individual nations and the wider international community to face the crisis of resource depletion by integrating conservation and development. While it clarified threats to the environment through irrational and unmanaged resource use and allocation, it did not layout specific solutions. Instead it offered a process through which nations could respond to the priorities cited in the WCS to create their own national and regional conservation strategies.

The aim of the national or regional conservation strategy is to provide a framework for reviewing conservation priorities and obstacles, and to identify means to integrate conservation objectives into the mainstream of national and regional planning. As well, such strategies typically provide the means to co-ordinate the efforts of government agencies with conservation and social organizations to achieve shared objectives. Each national conservation strategy is a unique expression of that country's needs and objectives.

However, most strategies aim to fulfill three common functions, deriving from the WCS priorities:

- to establish priority requirements for achieving the three conservation objectives;
- to identify obstacles to meeting these requirements; and
- to propose cost-effective means of overcoming these obstacles (World Conservation Strategy, 1980).

A nation's conservation strategy is best viewed as an operational document, setting policy directions and actions for achieving the three conservation objectives. Yet, the process by which the strategy is developed is also very important, and the WCS offer guidance for the planning and analysis through which conservation strategies are formulated. The process of developing a national conservation strategy begins with three steps: strategic review, analysis, and action planning.

It is important to note that conservation strategy process of all relevant stakeholders for participation in providing the framework for implementing change. Consultation plays an important role in the process of developing conservation strategy, both at the national and sub-national levels. Most of the issues addressed by conservation strategies go beyond the scope of anyone sector of national life, or anyone department within an enterprise. When reviewing conservation objectives against development activities, it soon becomes clear that there are stakeholders and resource users among all sectors and strata of society. Including stakeholder groups in the conservation strategy process will enrich the process in several ways.

Broadly based, cross-sectoral involvement will increase the available to the process, helping to clarify the range of values and concerns that need to be addressed. Each sector or group that has a share in the allocation or utilization of natural resources will bring a unique perspective to a review of objectives and requirements. Ideally all departments, organizations, and stakeholders in conservation initiatives can be coordinated so that they are working together to meet conservation objectives. Bringing the various sectors together as the strategy is being developed can foster and strengthen these co-operative relationships. Finally, by involving multi-sector stakeholders in the process, the action plan of the conservation strategy is more likely to be accepted and promoted by a wider number of people (World Conservation Strategy, 1980). Thus, governments cannot implement a conservation strategy alone; public support and participation are crucial if the objectives of conservation are to be met.

Conservation Strategies in Nigeria

According to John (2009), a country that incorporates ecological sustainability into a genuinely national strategic development project aimed at drastically reducing food insecurity, developing a stable future, as well as enhancing the development of Nigerian species diversity for the advantage of both the Nigerian local economy in conformance with ecosystems sustainable development and social fairness. Nigeria has shown her dedication to conservation efforts by being members to various multilateral agreements for the protection, preservation and sustainable utilization of biological diversity (Federal Government of Nigeria 2015). As a result, the country actively participated in all of the negotiations that led to the adoption of the Convention on Biological Diversity, and it was one of the 153 signatories to the Convention at the United Nations Conference on Environment and Development. Following that, the country ratified the convention in 1994 and began the process of developing her Biodiversity Strategy and Action Plan. The Federal Environmental Protection Agency (FEPA) published "A Country Study Report" in 1993, which recorded the state of Nigeria's ecological variety, rules, regulations, and conservation efforts.

The present National Biodiversity Strategy and Action Plan (NBSAP) is a modification of the original proposed file that was created in 1998 as part of Global financial institution aid Environmental Protection Program. Using community-level discussions, eco-regional and nationwide conferences conducted by a Team of Experts, the review dealt with identified deficiencies in the prior publication. It discusses the provisions and spirit of the Convention, as well as the nation's aim for long-term growth (NBSAP, 2015).

The Strategic framework and programme of action goal is to "create a suitable framework as well as program devices for the conservation of Nigeria's biodiversity as well as its sustainable utilization by incorporating biodiversity considerations in the national development planning, policies, and decision-making procedures. The government has performed biodiversity surveys and inventories since the initial draft of the NBSAP, which served as the framework for formulating the National Plan towards Preservation, protection and Responsible Utilization of Species diversity. This approach would be a display of our commitments to coming generations as well as a component of our national obligations under the Constitution.

The Nigerian government has enlisted the help of scientists in government ministries and non-governmental groups to do background research and prepare a paper, which has now been resubmitted to national discourse for amendment and endorsement. The practical way to developing this method is to create an adaptable system that creates national objectives, policies, and structures for dealing with the issues on: Biological diversity protection and preservation; Sustainable utilization of ecosystem goods and services; Equal distribution of benefits; management of agro-biological diversity; Bio-safety; and Biological diversity – Company's border.

The NBSAP was developed and reviewed with extensive involvement from different federal and state government agencies; academics, non-governmental groups, as well as local economies via global and sub-national consultation conferences. Professionals from many industries as well as bridge concerns provided a variety of literature review for the Strategy. The Federal Ministry of Environment formed a Nationwide Working Group as well as a Bio - diversity Technical Group throughout the creation of the Strategy.

Participants at the Workshops agreed that poverty is the greatest danger to the management of Nigeria's biodiversity. It was established that greater than seventy percent of Nigerians live in rural areas and rely heavily on forest products, wild plants and animals for food as well as income supplementation. By tackling the core issue of poverty, the Strategic plan and program of action will seek to secure long-term utilization of biological diversity. It will create a program for rural community involvement that will return a major share of the conservation benefits. The Strategy too has prompted a policy change toward decentralization and local engagement in natural resource management as a more sustainable means of promoting conservation-oriented decision-making and biological diversity protection.

CONCLUSION AND RECOMMENDATIONS

Forest resource conservation is a national issue that must be addressed with perfect coordination between the forest department and other departments in the country. Thus, stakeholder's involvement in forest resource conservation is critical. The development of conservation strategies alongside proper implementation of these strategies by various stakeholders will ensure sustainable conservation of these resources. The emphasis should now be on providing support for actual implementation, based on existing best practices and tools as well as monitoring progress on the ground to provide feedback to national and international policy processes.

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Deterrent Methods for Mitigating Crop Raiding By Primates in the Communities around Kainji Lake National Park, Nigeria

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K E Y W O R D S

Primates,
Crop damage,
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Mitigating losses

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A B S T R A C T

The study identified the deterrent methods employed to prevent crop damage and economic losses in the Support zones of Kainji Lake National park, Nigeria. There is a general perception that primates living at the edge of reserve boundaries are often agricultural pests. Direct method and structured questionnaire were used to obtain information on preventive methods used and it effectiveness in mitigating crop damage by primates. Purposive sampling technique was used for ten (10) communities with serious presence of human-primate conflict. Simple random sampling technique was adopted in selecting respondents from each community. Descriptive statistics and Chi-square test analyses were adopted to investigate the opinions of respondents for significant differences. The results revealed that the various deterrent methods mostly used include, trapping, killing, scare crow, shouting, fencing and stoning which were adopted by 17.8%, 15.5%, 8.9%, 14.5%, 10.2% and 3.3% of the respondents respectively. Majority of the respondents (57.8%) indicated guarding method as the most effective method of preventing crop damage. With respect to the methods and strategies adopted for crop protection, opinions of respondents were also unequally divided, depending on which method or strategy fitted any particular situation ($P < 0.05$). Guarding method is the most effective method of preventing primates from crop damage in view of their diurnal foraging behaviour. Since most deterrent methods used by local farmers did not take into consideration affordability and use, more methods which must be absolutely effective, affordable and can be operated by the local dwellers be developed.

INTRODUCTION

Human-primate conflict resolution is important in reducing the vulnerability of people that come into conflict with wildlife, by reducing the magnitude of wildlife damage sustained (Dickman, 2010). If problems are allowed to persist, losses will only get worse and difficulties in management magnified (Engeman *et al.*, 2010). Furthermore, providing solutions helps encourage positive attitudes towards wildlife so that peaceful human wildlife coexistence can be maintained (Strum, 2010). There are a number of deterrent methods that are currently implemented by agriculturalists that suffer from damage by wildlife. These include: guarding, chasing, beating drums, throwing stones, slingshots, spears, bear bangers, ultrasound, dogs, scarecrows, chilli bombs, translocation, culling, a range of fencing including electric, fladry, buffer crops, and many more (Kaplan, 2013).

However, most of these methods are employed with limited effectiveness and could be significantly improved. Most control strategies will require some form of investment in either manual labour or capital (Wang *et al.,* 2016). Therefore, an important consideration is whether the management strategy is appropriate and affordable to the community concerned. It is extremely important to gather knowledge of the context of crop raiding at any study site, both from an ecological and social stand point, before implementing mitigation strategies. It is unlikely that a single management strategy will prevent all crop damage by all problem animals (Wang *et al.,* 2016), and therefore a combination of techniques should be used.

There is a general perception that primates living at the edge of reserve boundaries are often agricultural pests and can pose considerable costs to cultivators living in their vicinity(Naughton-Treves, 1998). Such perception is based on a large body of literature from studies conducted in Africa and Asia which reported that members of the genera Macaca, Papio and Cecrcopithecus are among the most frequently cited primate pest species and that they can impose considerable losses to farmers by destroying crops (Paterson and Wallis, 2015). This leads to development of negative attitude towards primate conservation as they are seen as nuisance and pest (Kivai, 2008), and consequently killed.

However, information on primates crop damage and control measures adopted in locations surrounding the Kainji Lake National Park are scanty. Therefore, the development of adequate strategies to minimise primates conflict impacts on local livelihoods, which can reverse the negative attitude by the people towards primates is constrained by scarce information.

MATERIALS AND METHOD

Study Area

Kainji Lake National Park (KLNP) which has a savannah climate is located in the North-West central part of Nigeria between Niger and Kwara States with coordinates Latitudes 9º 40'- 10º 20' N, and Longitude 3º 40' – 5º10'Eand a total area of 5,340.82 (sqkm). The area has two distinctive sectors known as the Borgu and Zugurma Sectors (Marguba, 2002). (KLNP) was established as Premier Park in Nigeria on 29th July 1979 by the amalgamation of the two existing Game Reserves, Borgu and Zugurma sectors under decree 46 of 1976 replaced by decree 36 of 1991. Zugurma Sector covers an area of 1370.89km^2 and it is situated in Mashegu Local Government Area of Niger State while Borgu sector is located in Borgu Local Government Area of Niger State in Kaiama and Barutten Local Government Areas of Kwara state. It covers an area of 3970.02sqkm. Both sectors (Zugurma and Borgu) are separated by the Kainji Lake, a lake impounded on the river Niger for hydroelectric power generation (Eleazor, 2002) as shown in Figure 1.

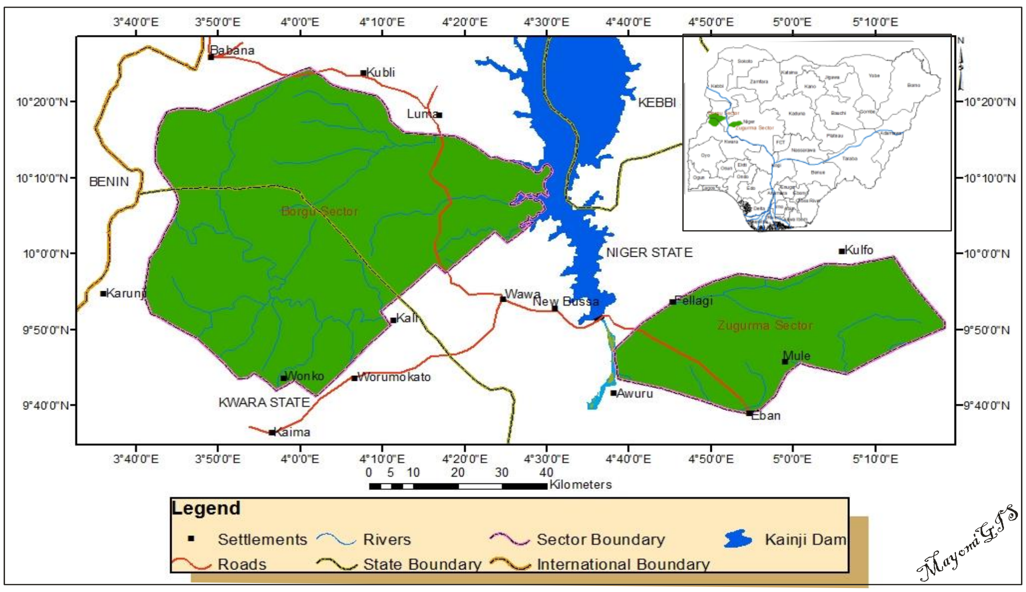

Figure 1: Map of Kainji Lake National Park
Source: Digitized from Google Earth Pro (May, 2018): GIS Laboratory, Dept. of Geography, University

Sampling technique and data collection

Purposive sampling technique was used in data collection. This involved the selection of communities with serious presence of human-primate conflict in the study area. A total of ten (10) communities having serious human-primate conflict were identified and selected. The communities included Mazakuaka, Felegi, Patiko, Woko, Worumakoto, Kemanji, Luma, Kulho, Ibbi and Dekara. Simple random sampling technique was then applied to select respondents from each community. The respondents included farmers, civil servants, traders, students, pastoralists and hunters. The number of respondents selected in each community shown in (Table 1)was determined using the probability proportional formula as adopted by Amaja *et al.*, (2016).

Table 1: Number of Respondents randomly selected from each community

Community	Population	Number of respondents sampled
Mazakuka	150	15
Feleji	200	20
Patiko	149	15
Woko	150	15
Worumakoto	200	20
Kemanji	499	50
Luma	500	50
Kulho	350	35
Ibbi	530	53
Dekara	300	30
Total	**3028**	**303**

Source: KLNP office (2019)

Data Analysis

Data collected were analyzed using SPSS version 20 software and MS Excel. Accordingly, descriptive statistics (frequency, percentages and cross tabulation) was used in analyzing the types of deterrent method and it effectiveness by farmers. Chi-square test analysis was also adopted to reveal the opinions of respondents for significant differences.

RESULTS

Table 2 presents different deterrent and preventive measures adopted to deter primates from invading or damaging crops in the areas around the park. As a measure, 70.6% of the respondents protected their crops in one form or the other while 29.4% did not. About 60% of the farmers used guarding as the primary method of crop protection, while 40.4% did not. On the other hand, trapping, killing, scare crow, shouting, fencing and stoning were adopted by 17.8%, 15.5%, 8.9%, 14.5%, 10.2% and 3.3% of the respondents respectively as means of ensuing crop protection. However, about 30% of the respondents indicated that nothing was adopted to protect their crops. With respect to the methods and strategies adopted for crop protection, opinions of respondents were also unequally divided, depending on which method or strategy fitted any particular situation ($P < 0.05$).

Table 2: deterrent methods adopted for crop protection against primate damage

Variables	Frequency	Percentage	P
Protection			
Yes	214	70.6	0.00
No	89	29.4	
Total	303	100	
Use guarding as the primary method			
Yes	180	59.6	0.00
No	122	40.4	
Total	302	100	
Other strategies adopted for crop protection			
Nothing	90	29.7	0.00
Trapping	54	17.8	
Killing	47	15.5	
Scarecrow	27	8.9	
Shouting	44	14.5	
Fencing	31	10.2	
Stoning	10	3.3	
Total	**303**	**100**	

$\alpha = 0.05$

Source: Field survey (2019)

Table 3 presents effectiveness of deterrent Methods adopted for crop protection against primate. About 10.2% of the respondents are of the opinion that the methods are very-effective, 57.8% believed that the methods are effective while 32% noted that the methods were not-effective, going by their assessment of the situations. In terms of the effectiveness of the methods and whether lethal prevention methods should be adopted, respondents were unequally divided with responses skewing towards non-adoption of lethal methods ($P < 0.05$).

Table 3: Effectiveness of deterrent Methods adopted for crop protection against primate

Variables	Frequency	Percentage	P
Effectiveness			
Very effective	31	10.2	0.00
Effective	175	57.8	
Not effective	97	32.0	
Total	303	100	

$\alpha = 0.05$

Source: Field survey (2019)

DISCUSSION

There were several strategies and deterrent methods of control and prevention adopted to deter primates from damaging crops in the areas around the park. More than 70% of the respondents adopted one form or the other methods to protect or prevent crop raiding. The use of guarding method seemed to be the primary method of choice to many farmers and was adopted by 60% of the respondents. Other methods such as trapping, killing, use of scarecrow, shouting, fencing and stoning were used by not more than 10% of the respondents in the study area. These findings agree with the report of Mosissa *et al.* (2017) who observed that the most commonly used methods to protect crop from primate raiding was guarding. Since primates are diurnal, guarding proves to be an effective strategy for the protection of crops from damage and it can be done by watching or by using dogs. However, chasing primate from one field may simply move them to the next field .Mosissa *et al.* (2017) reported that Scarecrow is one of the traditional indigenous methods in which farmers used different models that resemble humans but, since primate are intelligent the method is not effective. Fencing was not found to be effective as primate can easily cross over fences. Akosim *et al.* (2010) reported that fencing and smoking were not effective for protection against crop raiding by Baboon. It is implied from the findings of this study that there is yet no absolutely effective method of protecting the farms from being raided by the primates. An important consideration in developing any effective method is its affordability. It is therefore necessary that effective technique be developed through the improvement of the existing traditional deterrent methods. This observation agrees with the report of Sillero-Zubiri and Switzer (2001) that effective methods must take into consideration affordability and the ability of the local farmers to use it.

CONCLUSION AND RECOMMENDATIONS

The findings on deterrent method adopted and their effectiveness revealed that guarding among all the methods of crop protection against raiding by primates proves to be more effective than any other methods. However, it still does not offer absolute protection against the raiding of crops by primate species in view of their diurnal foraging behaviour. Since most deterrent methods used by local farmers did not take into consideration affordability and use, it is recommended that more methods which must be absolutely effective, affordable and that can be operated by the local dwellers be developed. For example, locally available materials, fences, solar lights, digging trenches, alarms and repellents chilli powder.

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Determination of some Anatomical Properties of Acetylated Bamboo (*Bambusa vulgaris* Schrad.) for Construction Applications

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ABSTRACT

Due to its high specific strength and renewability, bamboo fiber has generated a lot of interest. At the University of Ibadan, Nigeria, five matured bamboo plants (Bambusa vulgaris) with comparable heights and internode counts were cut down at a height of 30 cm above the ground. Modified bamboo test samples with dimensions 20mm (tangentially) x 60mm (longitudinally) x 5mm (radially) as well as the unmodified test samples with the same dimensions from each individual culm were used for this study. Test samples were sliced into match stick size splints with one side blade and placed into test tubes. Splints were macerated with an equal volume (1:1) of 10% glacial acetic acid and 30% Hydrogen Peroxide (H_2O_2) at 100±2˚C, the macerated slivers were boiled in a water bath at a temperature of 100°C for 10minutes. Results show that rate of reaction mean range between 0.95 to 1.41% with a marked effect along culm height. Fibre length shows no significant differences between the treated and the untreated samples with a mean of 1.78 to 2.44mm. The fibre diameter, lumen width and cell wall thickness of bamboo showed positive correlation between the treated and the untreated bamboo samples with mean of 9.65 to 13.24µm, 2.35 to 4.62µm and 7.32 to 9.1µm respectively, along the sampling height. The strength of the bamboo fiber is relatively greater among the plant fibers and its superior mechanical properties originate from the intricate lamellar structure of its cell wall is excellent for construction purposes.

INTRODUCTION

As a fibre, bamboo is a natural cellulosic regenerated biodegradable environment friendly textile material. Not only a green fibre but it has also inherent property of anti-bacterial and ultraviolet protective property, which makes it a unique ecofriendly textile material in 21st century (Jia *et al.,* 2022). Bamboo is considered a fast-growing plant that is widely used for the manufacture of handicrafts, baskets, furniture, and general merchandise (Rathour *et al.,* 2022). The use of bamboo has evolved from traditional to more value-added products. According to Xing *et al.,* (2015), bamboo can be regarded as the best alternative for replacing timber because bamboo has high strength and is fast-growing. As stated by Krause and Ghavami (2009) and Cui *et al.,* (2020), bamboo in its round form demonstrates excellent mechanical properties that make it useful for the construction industry and can reduce the need for steel. Bamboo is a cylindrical, usually hollow, light-weight, and functionally-graded material that demonstrates optimal characteristics for building truss elements that are frequently used in civil construction. It is crucial to comprehend the fundamental anatomical, physical, and mechanical characteristics of bamboo in order to determine whether it is suitable for the planned uses given the wide range of uses for which it is now used.

According to Razak *et al.,* (2010), Wang *et al.,* (2016), and Siam *et al.,* (2023), the anatomical properties of Bamboo are significant because of how they affect mechanical characteristics, preservative absorption, and characteristics of finished goods, particularly pulp and paper. Anatomical properties can also influence the bamboo's durability, toughness, workability, and strength (Razak *et al.,* 2010; Akinlabi *et al.,* 2017). These findings were further supported with a study by Xin *et al.,* (2015), where it was concluded that the anatomical structure of bamboo is basic knowledge for understanding the physical and mechanical properties as well as the utilizations of the bamboo.

Bambusa vulgaris is an erect, evergreen, clump-forming bamboo growing 15 - 20 metres tall. The thin-walled, hollow canes are 40 - 120mm in diameter with internodes 20 - 45cm long. The plant has a very wide range of uses and is a very important component of the local economy in many areas of the tropics. It is widely cultivated in the tropics and subtropics both as an ornamental plant and for its many uses. It adds a particularly tropical forest appearance where it is planted, though it needs a lot of space to spread. They are secured by sheaths at the underlying phases of development that tumble off as the plantling develops. The distance between two nodes between nodal length changes extensively crosswise over bamboo species, going from five to more than sixty centimetres. Generally, the nodal length between two nodes increments upwards along the culm from the lower part to the centre, and after that reduces. For the most part cross segment of bamboo have filaments from which the mechanical properties of bamboo shift. The properties may shift in light of the idea of development, climatic conditions and soil dampness condition (Kaur *et al.,* 2017).

Since bamboo is susceptible to environmental degradation and there is need for modification to enhance its workability. To protect the lignocellulosic material from degradation and enhance its service life for structural uses, various treatment methods have been employed during last few decades such as treating with mineral oil, coal tar; heating in hydrocarbon oil, smoking, treating with various etherifying and esterifying agents, acetals, alkylene oxide and alkoxysilane-coupling agents and have been documented by several researchers (Amin *et al.,* 2021). Acetylation is a reaction that introduces an acetyl functional group (acetoxy group, CH_3CO) into an organic chemical compound namely the substitution of the acetyl group for a hydrogen atom (Danouche *et al.,* 2021). The reaction occurs between the hydroxyl groups of the polymers and the reagent molecules and leads to a change in the chemical and physical properties of the woody products.

Finding more environmentally friendly construction methods for development is our obligation because the building sector indirectly contributes significantly to environmental damage (Riki *et al.,* 2020). One of the solutions is to search for a new material that can be recycled and reused. Therefore, it is necessary to go for a new material that is naturally available such as bamboo (Rajesh *et al.,* 2019). Bamboo is one of the renewable natural resources known to us. But sufficient care has not been given to investigation and change in bamboo (Awoyera *et al.,* 2019). Due to the beneficial physical characteristics of bamboo, research has been made of bamboo as fiber material in concrete (Banu *et al.,* 2019; Ayande *et al.,* 2020 and Momoh *et al.,* 2022). Siam *et al.,* (2019) studies the anatomical, physical, and mechanical properties of thirteen Malaysian bamboo species while Ajayi *et al.,* (2022), earlier studied suitability of selected physical properties of acetylated Bamboo (*Bambusa vulgaris*) for structural uses in Nigeria and they have both proven that the species is durable for construction purposes. With the development of science and technology, new techniques are implemented for treating of bamboo to make it durable and more working in terms of construction materials. Therefore, for bamboo to be able to serve as a substitute for wood, its properties need to be improved. This study investigates fibre characteristics of bamboo for construction purpose.

MATERIALS AND METHODS

Description of the Study Area

The study was carried out at University of Ibadan, Ibadan, Oyo State. Nigeria, which is sited 3km to the North of the city of Ibadan. The University of Ibadan is located between latitude 7°23' and 28°19′N, and longitude 3°54' and 59°99'E. The topography of the area is flat and undulating, in terms of climate classifications, the altitude of the area ranges from 150 m to 275 m. The mean total rainfall for Ibadan is 1420.06 mm, falling in approximately 109 days. There are two peaks for rainfall, June and September. The mean maximum temperature is 34.4°C, minimum 18.07°C and the relative humidity is 74.55% (Riki *et al.,* 2021).

Collection of Samples

Five mature Bamboo (Bambusa vulgaris) with equal height and internodes numbers were harvested at a height of 30cm above the ground level from a bamboo grove naturally growing but managed by the Biodiversity Management Committee, University of Ibadan, Ibadan, Nigeria (Ajayi *et al.,* 2022).

Specimen Preparation

Bamboo culms were marked at each internode using permanent marker from the base to the top to allow for easy identification and re-arrangement of the culm. The culms were thereafter cut across the nodes with the aid of a hacksaw for accessibility and easy transportation. Each internode was placed in a separate jute bag to avoid contamination from soil. The culms were then transported to and stored for 5 days in the wood workshop of the Department of Forest Production and Products, University of Ibadan, Ibadan, Nigeria for conversion to test specimens.

The culms were carefully sawn with circular sawing machine longitudinally into strips. Each strip was planed on both the inner and outer surface, using a planning machine, in order to obtain the bamboo timber devoid of the outer protective skin with mean culm thickness of 5±0.5mm for the tests. The bamboo strips obtained were further converted to test samples according to EN 113 (1996) test standard. From each internode, 5 test samples were obtained, the total number of test samples converted was 625 samples. The test samples with dimensions 20mm (tangentially) x 60mm (longitudinally) x 5mm (radially) were oven dried at 105± 2°C until constant weight is achieved to determine the dry weight before acetylation (Ajayi *et al*., 2022).

Acetylation of Bamboo Samples

The oven dried bamboo specimens were weighed (Wo) and recorded with the use of digital weighing balance of 0.01 precision, the dimensions of the test samples were measured using digital venier calliper and used to estimate the volume of the test samples. Substantial volume of acetic anhydride was poured into the reaction vessel and the oven dried specimens of known weight were subjected to non-pressure hot treatment for 10 hours using a constant heat of 100°C as the only catalyst (the treatment took place in a closed reaction vessel which was tightly wrapped with aluminium foil to prevent evaporation and contamination). After 10 hours, the specimen was brought out of the reaction vessel, rinsed with distilled water to arrest the reaction and dried with the aid of filter paper. The dried modified specimens were then oven dried at 105°C for 24 hours and allowed to cool in a desiccator. The weight of the treated specimens were determined (Wt) using digital weighing balance, the volume was also estimated by measuring the dimensions using digital veneer calliper (Ajayi *et al.,* 2022).

Determination of modifiability of Bamboo

Determination of Percent Weight Gain (WPG)

The weight percent gain (WPG) of the treated bamboo samples was calculated on an oven-dried weight basis by measuring the extractive-free untreated specimens and the treated specimens using the following formula:

$$\mathrm{WPG} = \frac{W_t - W_o}{W_0} x \frac{100}{1} \qquad (1)$$

Where: *WPG* is the weight percent gain, W_o is the weight of oven-dried sample before acetylation (g), W_t is the weight of oven-dried sample after acetylation (g).

Determination of Bulking Coefficient

The bulking coefficient (B) was also determined for all prepared specimens using the following formula.

$$\mathrm{B} = \frac{V_t - V_o}{V_0} x \frac{100}{1} \qquad (2)$$

Where: *B* is the bulking coefficient, *Vt* is the volume of oven-dried wood after being acetylated, V_o is the volume of oven-dried wood before acetylation

Determination of Rate of Reaction

The rate of reaction was calculated using the following formula.

$$R = \frac{WPG}{t} \qquad (3)$$

Where: R is the rate of reaction (% · h^{-1}), WPG is the weight percent gain (%), t is the reaction time (h).

Determination of Anatomical Properties of Acetylated Bamboo

Anatomical Characteristics test

Studies on anatomical characteristics were carried out in accordance with the ASTM D 1030-95 (2007) and ASTM D1413-61 (2007). Modified bamboo test samples with dimensions 20mm (tangentially) x 60mm (longitudinally) x 5mm (radially) as well as the unmodified test samples with the same dimension from each individual culm were used for this study. Test samples were sliced into match stick size splints with one side blade and placed into test tubes. Splints were macerated with an equal volume (1:1) of 10% glacial acetic acid and 30% Hydrogen Peroxide (H_2O_2) at 100±2˚C, the macerated slivers was boiled in a water bath at a temperature of 100°C for 10minutes following the procedure adopted by Ogbonnaya *et al.,* (1997) and bleached white with 10% domestic bleach. The slivers were washed on a sieve, placed in 30ml-test tubes with 20ml-distiled water and shaken vigorously to separate the fibre bundles into individual fibre. The macerated fibre suspension was then carefully aligned on a slide and air dried.

The resulting images were viewed on Rheichert visopan microscope screen and measured using a stage micrometer and an eyepiece micrometer for fibre length, diameter, lumen width and cell wall thickness.

Statistical Analysis

A one-way analysis of variance (ANOVA) was used. Data were subjected to statistical analysis of 2 × 25 factorial experiment in a completely randomized design (CRD) and Mean±SEM. However, a follow-up test was carried out using the least significant difference test (LSD) at 5% level of probability.

RESULTS AND DISCUSSION

Rate of reaction for Acetylated Bamboo

There was a remarkable effect in the rate of reactions across the culm heights. The mean range between 0.95 to 1.41% as presented in Table 1. Also, the mean weight percent gain (WPG) for all the acetylated bamboo samples ranged from 11.41% to 16.88% across the culm heights with positive difference among the samples across the culm height**.** The results obtained for the bulking coefficient of the sampled wood species show that significant differences were observed among the twenty-five-culm height at 5% probability level. The mean values were ranged 3.21% to 4.75% for the culm height as previously reported by Ajayi *et al.* (2022)**.**

Table 1: Analysis of variance for Rate of reaction of Acetylated Bamboo

Properties	Source of variation	Df	SS	MS	F	Sig,
Rate of reaction (%h^{-1})	Culm position	24	15.771	0.657	4.700	0.001*
	Error	50	6.991	0.140		
	Total	74	22.762			

Note: "*" Significant at $p<0.05$.

Determination of Anatomical Properties of Acetylated Bamboo

Fibre Length

The result of the Fibre length of the study samples are presented in figure 1. The mean value obtained were ranged 1.78 to 2.44mm for both the treated and the untreated samples. The result of the analysis of variance of fibre length for the acetylated bamboo sampled are presented in the Table 2. There were no significant differences observed within the treated and the untreated. A significant difference was shown in the fibre length along the culm height at 5% probability level.

The bamboo fibres play an important role in the supporting of bamboo self-weight. The fibres are ground in fibre strands as reported by Wang *et al.,* (2011). It was observed that the fibre length had a gradual but steady increase from the base to a point at the middle before it then decreases progressively towards the top. These observations is in accordance with the findings and documentation of Abd-Latif *et al.,* (1994) who also observed similar variation in Malaysian bamboo (*Gigantochloa scortechinii*). Liese (1998), gives an insight into why these is so, he reported that this variation pattern of fibre length along the culm height could be attributed to the correlation between fibre length and internode length as there are longer internode at the middle compare to the top and the base. Wang *et al*., (2011) reported that the longest fibre length located at the middle segment and the longer at the base with the top segment having the shortest fibre length. However, Pu and Du (2003) reported that the longest fibre length was located in the bottom culms while the shortest fibre length was recorded at the top of the culm. Abd-Latif and Mohd-Tamizi (1992), concluded that the variation trends which were found among various bamboo species across the globe might have resulted from the difference in growth rates among different bamboo species. The bamboo has longitudinal alignment of fibre due ro its inherited property. Compared to any other natural fibre material bamboo fibre having higher modulus of elasticity. The lengthier the fibre advanced it gives the tensile strength. Adding of Bamboo fibres to the concrete increases the tensile and mechanical strength (Kumarasamy *et al.,* 2020).

The strength of the bamboo fiber is relatively greater among the plant fibers (Li and Shen, 2011). Its superior mechanical properties originate from the intricate lamellar structure of its cell wall. The tensile strength of bamboo is generally more than 2 times that of wood, and the specific tensile strength of bamboo is about 3–4 times that of steel (Yu *et al.*, 2011).

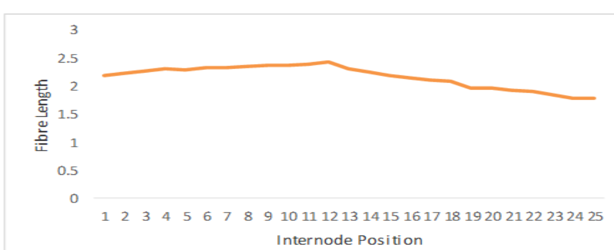

Figure 1. Trend of fibre length variation in acetylated bamboo along the culm

Table 2: Significance (p-values) of Anatomical Morphology along bamboo culm sampling heights

SOURCE	Df	FL	FD	FLW	CLT
Treatment	1	1.000^{ns}	0.000*	0.000*	0.000*
Culm Position	24	0.000*	0.000*	0.000*	0.000*
Treatment * Culm Position	49	0.000*	0.000*	0.000*	0.000*
Error	100				
Total	150				

Notes: *p-values > 0.05 are not significant. DF = Degree of freedom, FL = Fibre length, FD = Fibre diameter, FLW = Fibre Lumen width, CLT = Cell wall thickness.

Fibre Diameter

The mean value obtained of the sampled treated bamboo for fibre diameter after observed on Rheichert visopan microscope screen and measured using a stage micrometer and an eyepiece micrometer were ranged 9.65 to 13.24µm. The mean value observed for the untreated ranged 13.81 to 15.24µm (Figure 2).

The result of the analysis of variance for fibre diameter showed a significant difference between the treated and the untreated bamboo samples. Significant differences were also observed within the height along the culm. There is a significant difference in the interaction of the treatment and the culm height at 5% probability level as presented in Table 2.

The fibre diameter is an indicator of the relationship between the cell-wall thickness and the lumen width (Riki and Oluwadare, 2020). Fibre diameter decreased from base to top along the longitudinal position. The observed trend could be due to the fact that minimal net photosynthate for cell development at the top caused by competition for leaf and branch development lead to better cells production at the base (Ogunleye *et al*., 2017).

Monteiro *et al*., (2017), investigated the effect of diameter on the mechanical resistance of bamboo fibers extracted from the stem of the giant bamboo (dendrocalmus giganteus) as possible composite reinforcement due to their relatively high tensile strength. They found that the thinnest fibers of the giant bamboo exhibit a maximum tensile strength of about 300 MPa. As mentioned above, the superior mechanical performance highly depends on its arranged orderly thick-wall structure. Specifically, the bamboo cellulose content gradually increases from the inner yellow portion to the outer bamboo green portion, providing excellent fracture resistance. The vascular bundles on the outer side are stronger and stiffer than those on the inner side along the cross-section. In addition, for vascular bundles of varying heights, the strength and modulus of the top part are nearly equal to that of the middle part but higher than that of the base part (Gao *et al*., 2022).

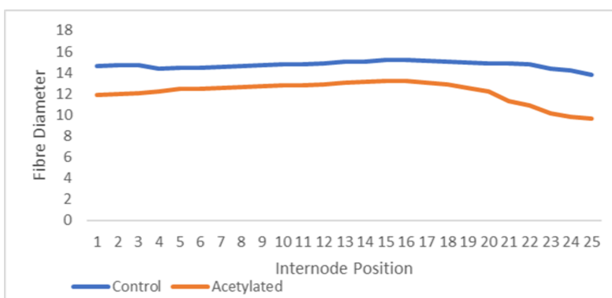

Figure 2: Trend of fibre diameter variation in treated and untreated bamboo samples along the culm

Fibre Lumen Width

The mean value obtained of the sampled treated bamboo for fibre lumen diameter after observed on Rheichert visopan microscope screen and measured using a stage micrometer and an eyepiece micrometer were ranged 2.35 to 4.62µm. The mean value observed for the untreated ranged 8.36 to 10.63µm (Figure 3).

The result of the analysis of variance for fibre lumen diameter showed a significant difference between the treated and the untreated bamboo samples. Significant differences were also observed within the height along the culm. There is a significant difference in the interaction of the treatment and the culm height at 5% probability level as presented in Table 2.

Lumen size is important for fibre dimensions because of its effect on the rigidity and strength in construction materials (Akpakpan *et al*., 2012). The cell-lumen obtained in the stalk decreased along the sampling height which is in agreement with pattern observed for T. daniellii reported by Sotannde, (2015). The smallest lumen diameter was observed at the top and the base segment of the culm height. The results in this study is in consonance with the work of Su *et al*., (2005).

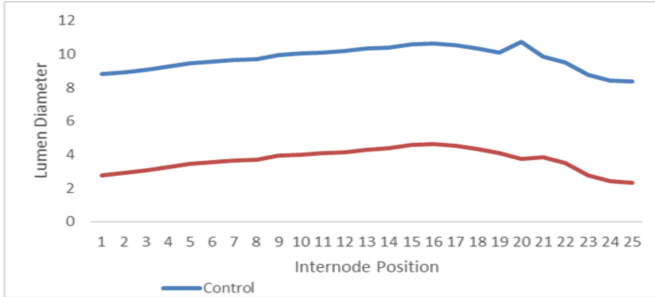

Figure 3. Trend of fibre lumen width variation in treated and untreated bamboo samples along the culm

Cell wall Thickness

The mean value obtained of the sampled treated bamboo for cell wall thickness after observed on Rheichert visopan microscope screen and measured using a stage micrometer and an eyepiece micrometer were ranged 7.32 to 9.1μm. The mean value observed for the untreated ranged4.61 to 5.87μm (Figure 4)

The result of the analysis of variance for cell wall thickness showed a marked effect between the treated and the untreated bamboo samples. Significant differences were also observed within the height along the culm. There is a significant difference in the interaction of the treatment and the culm height at 5% probability level as presented in Table 2.

The cell wall of bamboo fiber highly affects its mechanical performance. The bamboo cell wall structure is more complex than that of wood (Huang *et al*., 2016). Fei *et al*., (2016), examined the bamboo cell wall using a light microscope and found more cell layers near parenchyma cells across the bamboo vascular bundle and at the inner edge of the vascular bundle. Cellulose is the structural skeleton of a bamboo cell wall, and its molecular bundles aggregate to form microfibrils. The micro-fibril angle (MFA), which may be determined using XRD or wide-angle X-ray scattering (WAXS), is the angle between the arrangement direction of microfibrils and the main axis of the cell (Li and Shen, 2011).

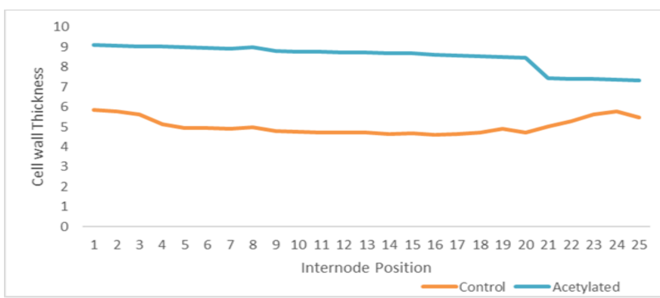

Figure 4. Trend of fibre cell wall thickness variation in treated and untreated bamboo samples along the culm

CONCLUSION

This study therefore establishes the fact that bamboo could be chemically modified using acetic anhydride to improve its anatomical properties and as a result of the modification in the bamboo fibre cell wall, there is a significant improvement in its dimensional stability and hydrophobicity hence, enhances the utilization of bamboo for structural application which may be due to its long fibre length. Bamboo with its high fibre length can be treated and use as alternative to wood as a construction material in order to reduce the pressure on wood and combat global warming.

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Effects of Pretreatment Protocol and Watering Regime on the Germination and Early Growth of *Irvingia gabonensis* (Aubry-Lecomte ex. O'Rorke) Baill

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K E Y W O R D S

Early growth,
Irvingia gabonensis,
Pretreatments,
Seedling growth,
Watering regime

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A B S T R A C T

The early stage of plants is the major determinant of their growth and yield. This study evaluated the germination rate and growth response of Irvingia gabonensis to different Pretreatments and watering regimes. The experiment was laid in a 3×4 factorial experiment in a completely randomized design (CRD) and replicated 15 and 7 times for germination and early growth studies, respectively. Three watering regimes; Watering once; W1=daily (control), W2=watering twice daily, and W3=watering once 2 days with four pre-treatments; P1=No treatment (control), P2= Soaking in water (23^{o}C) for 24 hours, P3= Soaking in warm water (43 ^{o}C) for an hour, and P4= Scarification. Seedling height (cm), collar diameter (mm), and Number of leaves were assessed for 12 weeks. The data collected were subjected to analysis of variance and means were separated using Duncan multiple range test at α=0.05. The results showed that P2W2 had the best performance in germination with first emergence on the 13th day and 100% germination on the 28th day. A similar result was recorded for P2W2 in seedling height (24.39±2.068 and 26.82±1.705cm), collar diameter (4.712±0.995 and 4.313±0.922mm), and number of leaves with a mean value of 1.78±0.698. The study concluded that Irvingia gabonensis seeds germinate and seedlings thrive better when soaked in water (23^{o}C) for 24 hours and watered twice daily, hence was recommended for mass seedling production.

INTRODUCTION

Irvingia gabonensis (bush mango), the source of "Ogbono" (Irvingia kernel) is one of the most important Non-Timber Forest Products (NTFPs) in West and Central Africa especially in Southern Nigeria (Ladipo, 2000). The most important part of *I. gabonensis* to rural people is its nutritious seeds, which have also been found useful in the reduction of cholesterol and body weight in obese patients (Ngondi, 2005). It is an edible African indigenous fruit tree that produces edible fruits and seeds (Atangana *et al*., 2002).

Irvingia seeds constitute an important part of the rural diet in Nigeria. The sun-dried seeds are ground into flour and used as soup thickeners (Ekpe *et al*., 2007). The white cotyledons are roasted and eaten in the Bwemba community of Uganda; roasted seeds confer flavour and aroma on foods especially vegetables (Ousseynou and Nicodeme, 1994). It is the food gum component of the seeds that serve as a thickening agent in water (Ndjouenkeu *et al*., 1996).

Bush mango is a valuable source of income for farmers and traders in Nigeria, where the fruit is traded locally (Ladipo, 2000). The kernels, which fetch a higher price than the fruits are traded regionally and internationally, which has given it the potential for a true commercial crop, and this has led to a more intensive collection in the forests. Despite the nutritional importance of *I. gabonensis*, there is a scarcity of large-scale plantations of the species for mass seed and fruit production. The existing stands of *Irvingia gabonensis* are mainly found in the traditional agro-forestry system and compound farms or homesteads. This creates the need for awareness in both yield potential and economic roles, to encourage more people to embark on large-scale plantation development and probably set up small-scale industries for seed export to many countries

Increased deforestation, urbanization, over-exploitation, and other industrial developments are major threats to forest species in Nigeria (Anozie and Oboho, 2019). Secondly, our knowledge of the optimal water requirements of most indigenous and exotic fruit tree seedlings that thrive in semi-arid and tropical environments is limited (Mng'omba *et al*., 2011). This knowledge gap constrains the ability of nursery operators to make informed management decisions about their operations (Mng'omba *et al*., 2011).

This research was aimed at finding out the response of this *Irvingia gabonensis* to various seed pre-treatments and watering regimes for mass seedlings production. This study will provide data that would be used in the determination of the best seed treatment that improved the seeds' germination and growth.

MATERIALS AND METHODS

The Study Area

This study was carried out in the Prof. E.L.C Nnabuife screen house at the Department of Forestry and Wildlife, Nnamdi Azikiwe University (NAU), Awka in Anambra State, Nigeria. The University is located in the South-eastern geopolitical zone of Nigeria and lies between latitude 6.245° to 6.283° N and longitude 7.115° to 7.121° E (Chukwu *et al*., 2020). Awka has seasonal climatic conditions; the rainy and the dry seasons with a short spell of harmattan. It has a rainfall pattern ranging from 1828 mm – 2002 mm (Chukwu *et al*., 2020).

Seed Source and Experimental Design

Matured ripe fruits of *Irvingia gabonensis* were sourced from Onistha, Anambra state, Nigeria. Top Soil was collected from the Departmental Nursery. Two hundred seeds were extracted from the fruits. Seed viability was tested by soaking in water, where floating seeds were seen as not viable while those that sunk were viable, a total of one hundred and eighty (180) seeds were used for the germination study.

The experiment was carried out for fourteen (14) weeks between August-November 2021. Four (4) pre-treatments were used for the experiment which includes; P_1=No treatment (control), P_2= Soaking in water at room temperature for 24 hours, P_3= soaking in warm water for an hour, Warm water is between 110 and 90 ^{O}F (43.3-32.2 ^{O}C) and P_4= Scarification. Three (3) watering regimes were used namely: Watering once; daily (W1), watering twice daily (W2), and watering once in 2 days (W3).

The experiment was laid in a 3×4 factorial experiment laid out in a completely randomized design (CRD) with 2 factors (watering regime and Pre-treatment) where factor1(watering regime) consists of three (3) levels and factor 2 (pre-treatment) consists of four (4) levels. The experiment was replicated fifteen (15) times for germination and seven (7) times for early growth.

Data Collection and Analysis

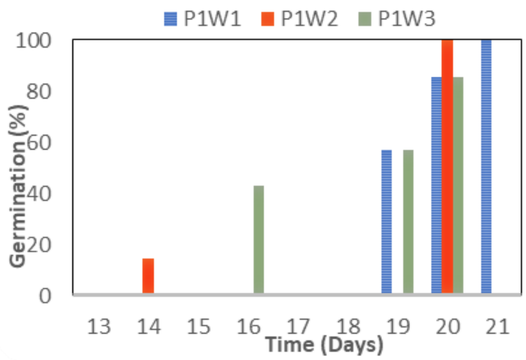
The germination count was taken daily and ended after 50 days. The germination percentage was calculated using equation (1).

$$Germination\ (\%) = \frac{Number\ of\ seeds\ germinated}{Number\ of\ seeds\ sown} \times 100 \qquad (1)$$

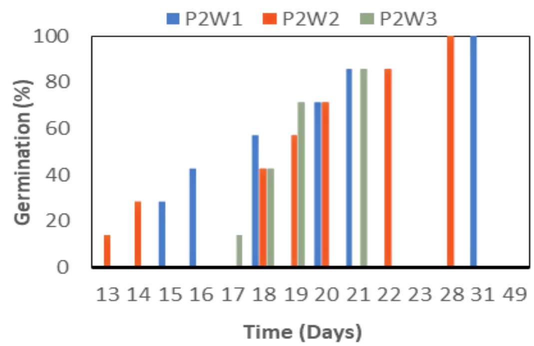
Eighty-four (84) seedlings of similar heights were selected for early growth assessment. Growth variables assessed are; height, number of leaves, and collar diameter on weekly basis. The Number of leaves was transformed using square root transformation. The growth variable data were then subjected to Analysis of Variance (ANOVA) and significant means were separated using Duncan multiple range test (DMRT) at 0.05 level of significance.

RESULTS AND DISCUSSION

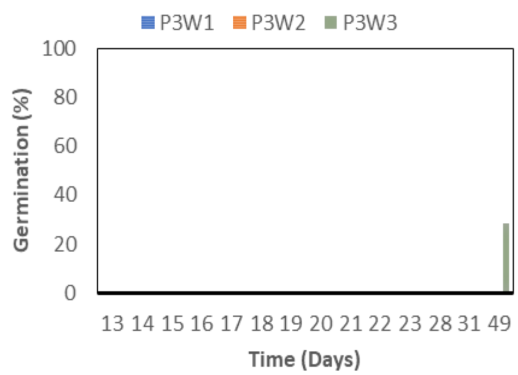
The result showed that P1W2 (control and watering twice a day) had the first seed emergence on the 14th day with a 100% germination rate on the 20th day, P1W1 (control and watering once a day) also had a 100% germination rate 21st day, While P1W3 (control and watering once in 2 days) had the least germination rate of 80% (Figure 1). This implied that viable seeds of *Irvingia gabonensis* can germinate without pretreatment once there is regular watering. Also, P2W2 (soaking in water for 24 hours and watering twice daily) had the first seed emergence on the 13th day with a 100% germination rate on the 28th day, P2W1 also had a 100% germination rate on the 31st day, While P2W3 had the least germination rate of 80%. This result was in agreement with Udosen and Sam (2015) who assessed the effects of pretreatment protocols on seed germination of *Irvingia gabonensis* (Aubry-lecomte exo'Rorke) Baill and found that the seed steeped in water for 24 hours before sowing gave 100% germination. According to Udosen and Sam (2015), the enhancing effects of the rehydration of seeds on germination may be due to the stimulating effect of rehydration on germination, which may be related to enzyme activities.



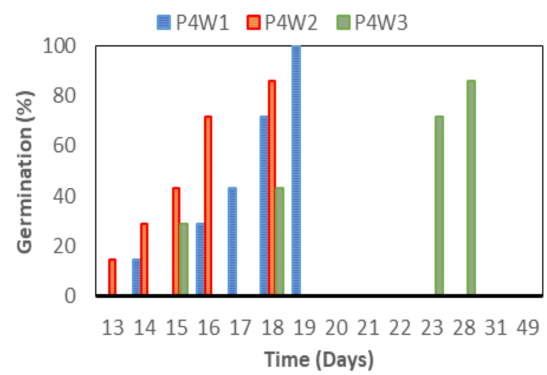
(a) Control



(b) Soaking in water for 24 hours



(c) Soaking in warm water for 1 hour



(d) Scarification

Figure 1: Seed Emergence and Germination and *Irvingia gabonensis* under different treatments

The post hoc result for seedling early growth under different pre-treatments showed that soaking in water for 24 hours had the highest means for stem diameter = 4.712±0.995 mm, Number of leaves = 2 ±0.698 and stem height of 24.39±2.068 cm, respectively (Table 1). This result is in agreement with Fredrick *et al.* (2016), that soaking the seed in water at room temperature enhances the germination of seeds and early growth of seedlings of tropical trees. However, the number of leaves and height (cm) of the seedlings showed no significant difference ($p>0.05$) in all the treatments (Table 1). Similarly, for the watering regime, watering twice daily gave the highest means for seedling growth variables: stem diameter (4.630±0.907 mm), Number of leaves (1.833±0.657), and height (26.820±1.705 cm). This is in agreement with Hsiao and Xu (2000) that regular watering allows the nutrient to dissolve and transport to the appropriate area for leaf expansion for photosynthesis which is necessary for plant growth.

Table 1. Summary of different pretreatment effects on height, stem diameter, and number of leaves of *Irvingia gabonensis* Seedlings

	Treatment	N	Mean ± Std. Dev.		
			collar diameter (mm)	Number of leaves	height (cm)
Pre-Treatment	Stratification (P4)	59	4.313±0.922^b	1.755±0.644^a	24.117±2.13^a
	Control(P1)	69	4.423±0.848^b	1.732±0.590^a	22.699±1.860^a
	soaking 24hrs(P2)	50	4.712±0.995^a	1.780±0.698^a	24.39±2.068^a
Watering Regime	Once daily(W1)	58	4.487±0.922^a	1.699±0.657^a	18.654±1.778^b
	Once 2 days(W3)	69	4.332±0.922^b	1.735±0.631^a	25.731±1.860^a
	twice daily(W2)	61	4.630±0.907^a	1.833±0.657^a	26.820±1.705^a

The means in a column with similar letters are not significantly different at 5% level of probability according to Duncan Multiple Range Test.

CONCLUSION AND RECOMMENDATION

The findings from the present study showed that *Irvingia gabonensis* seedlings responded to different pretreatment and watering regime on the germination and early seedling growth performance. That was explained by the increase in plant height, number of leaves, and collar diameter growth variables. This study concluded that the control (no pretreatment) and watering twice daily yielded the best seeds germination. For early growth of *I. gabonensis* seedlings, soaking in water at room temperature for 24 hours and watered twice daily gave the best performance. Therefore, soaking seeds of *Irvingia gabonensis* in the water at room temperature for 24 hours and watering twice daily is recommended for improving seed germination and seedling growth performance respectively for optimum seedlings production.

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Wildlife Conservation Awareness Level Among Secondary School Students in Imo State, Nigeria

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KEYWORDS

Wildlife Conservation,
Awareness,
Curriculum,
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Young children,
Secondary school.

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ABSTRACT

Wildlife has suffered a lot of threats in the hands of some humans because of a lack of conservation awareness. An investigation about the level of this awareness was carried out among senior secondary school students in three different secondary schools located at Owerri West Local Government Area of Imo State, Nigeria. These schools were Ihiagwa secondary school (ISS), El-Betty Model secondary school (EMSS), and Nekede secondary school (NSS). Random sampling was used to select thirty (30) students from each school and a total of (90) questionnaires were administered. Data were collected on personal characteristics of respondents (age, sex, and class) and conservation awareness. Descriptive statistics was used for analyzing the data obtained. The results obtained indicated that the highest respondents (73.3%) fall within the age bracket 13-16 years old. (8.9%) falls within the age bracket 9-12 years old, while none of the respondents (0.0%) fall into the age bracket 6-8. (57.8%) were females while (42.2%) were males. (37.8%) were from senior secondary one (SSI) while (31.1%) were from both senior secondary two (SS2) and senior secondary three (SS3) students respectively. The result of conservation awareness showed that (>70%) of the respondents were not aware of wildlife conservation ($P<0.05$) while (<30%) were aware ($P>0.05$). The conclusion of this study shows that majority of secondary school students were not aware of biodiversity conservation. This study recommends that conservation awareness education; mostly practice should be incorporated into the secondary school curriculum, to start on time to teach young children their responsibilities regarding wildlife conservation. Also to create conservation awareness in all levels of education, through outreach, posters, news broadcast, interviews, and public lectures.

INTRODUCTION

Conservation is an effort to maintain and use natural resources wisely (IUCN, 2010). It is an effort to ensure that those resources will be available for future generations (Ijeomah *et al*, 2012). Hence, wildlife conservation is meant to exploit wild populations reasonably so that they will be available for future generations (FAO, 2008). According to (Aina *et al*, 1992), the world is facing a biodiversity crisis, hence schools, teachers, and parents are being urged to prepare students to face the real-life issues they will routinely encounter in maintaining wildlife sustainably, manage the biosphere and integrate biodiversity conservation with other societal goals Ayodele, and Lameed (1990). The need for conservation awareness or education among juveniles is necessary to teach them on time about conservation. Conservation awareness is a process of disseminating information and knowledge about the sustainable use of wildlife resources and the ability to evaluate such information or knowledge for the benefit of mankind, wildlife, and the environment. (Chinedu, 2008). It aims to provide learners with the opportunity to gain sensitivity to wildlife and their environment (Nchor and Ogogo, 2012). According to (Jaya, 2005), conservation means to impart knowledge and experience to people. Conservation awareness assists communities to solve the problems surrounding the sustainable use of wildlife (Ibimilua, 2014). This will help them to acquire a set of values and positive attitudes towards conservation and to obtain the skills required to identify and solve wildlife-related problems (Nest, 2015).

Consequently, the motivation and ability to participate in the conservation of biodiversity lies on the level of individual awareness. Conservation awareness should be considered to include, not just formal education and training, but also public awareness-raising (e.g. posters and media campaigns), school environmental clubs, and transfer of indigenous knowledge from elderly people to young ones. (Jacobson *et al*., 2006). The ultimate goal of conservation awareness, whether it is formal or non-formal is to sensitize and create a positive attitude among people to use the knowledge they have acquired through various means of information dissemination to protect their environment (Agboola, 2014). Therefore, assessing young people's perception and level of awareness toward conservation, in general, can provide important insight into future wildlife conservation and management.

MATERIALS AND METHODS

Study area

The research was carried out in three Secondary Schools, namely Ihiagwa Secondary School (ISS), El-Betty Model Secondary School (EMSS), and Nekede Secondary School (NSS), all located at Owerri West Local Government Area of Imo State, Nigeria. This Local Government Area is located at the Rain Forest zone, about 120km north of the Atlantic coast. It has an area of about 295 km^2 and a population of about 99,265 at the 2006 census (P.D.A, 2014)

Geographically, Owerri West is located between latitude 5°43'26" N and 6°98'41" N and longitude 6°25'56" E and 6°58'48" E with an altitude of 720m above sea level. The temperature of Owerri West ranges from 23-37°C with a relative humidity of 90-100% in the rainy season and 70-80% in the dry season. The area is also characterized by high rainfall with an average of 3,000 mm per annum being recorded, while the dry season, lasts for up to four (4) months (December to March). The total population of the three schools was 941 of which ISS was 310, EMSS, and NSS have a population of 314 and 317 respectively.

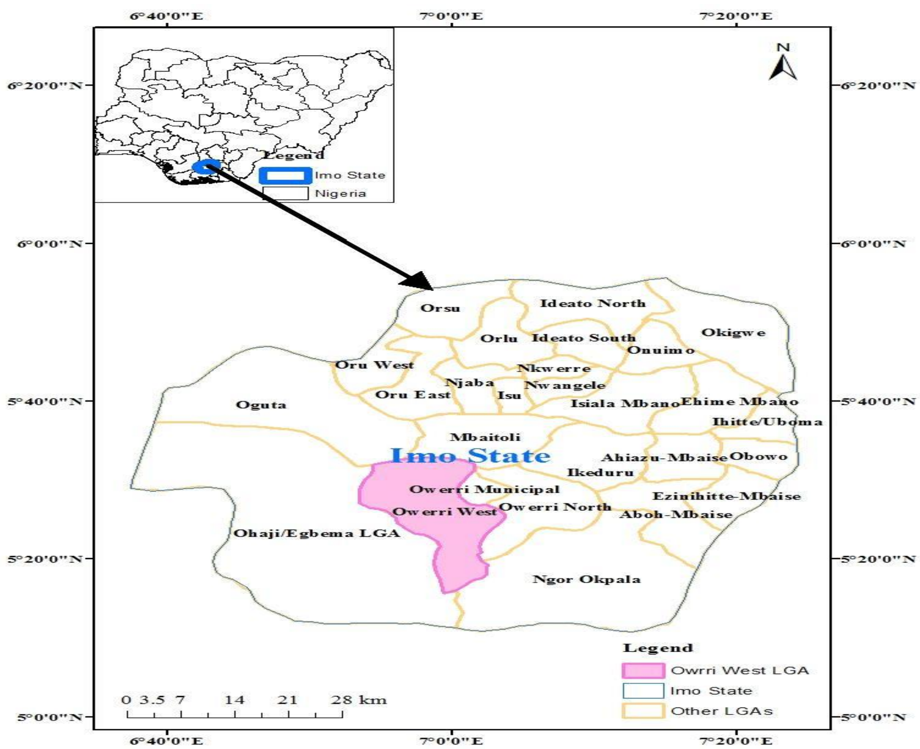

Figure 1: Map of Nigeria showing Owerri West Local Government Area
Source: Adeyemi and Ohwo (2015).

Method of data collection

Ninety (90) questionnaires were distributed in the three Secondary Schools, thirty in each school because they have an almost equal number of students. The total population was 941 of which 10% from each school were sampled. Initially, a reconnaissance survey was conducted in these study areas to guide the structure of the questionnaires as described by Verkevisser *et al.* (1991). Random sampling was used to select thirty students from each School, making it a total of ninety respondents. These three schools were visited at different weeks, on Mondays and Wednesdays within two months. Efforts were made to restrict the respondents from conniving in answering the questions. This was achieved by instructing the respondents to answer it like an examination question, strictly filling it independently, and return it at once. Teachers assistance were implored in making their students answer those questionnaires independently, which they did gladly. At the end, all the questionnaires (100%) were collected, without any loss (0%). Data was collected on some personal characteristics of the respondents (age, sex, and class). Many of the conservation awareness questions were in form of a Likert scale which varies from {Strongly Agree (SA), Agree (A), Disagree (D), and Strongly Disagree (SD)}.

Data analysis

Data which was collected from this study was analyzed with descriptive statistics. SPSS (statistical package for social science) and Microsoft Excel were used for the analysis of data. The results were represented in form of tables, charts, frequency and percentages.

Results and Discussion

Table 1 showed the results of the personal characteristics of the respondents on age, sex, and class. The highest percentages of respondents (73.33%) were in the age bracket 13-16 years old. This was followed by those in the age bracket 17-20 years old which was (14.44%). This could be because children go to school nowadays at a very early age, the age of adolescence, the prime of their youth. (8.89%) of respondents falls within the age bracket 9-12, while (3.33%) were >21 years old and none of the respondents were 6-8 years old. It might be because they were younger children and have not reached the age of secondary school. However, (58.78%) of respondents were females while (42.22%) were males. This could be attributed to the fact that females go to school in Owerri West more than males or the statistics that females are more than males in population. Senior secondary school students (SSS1) had the highest number of respondents of (37.78%), while senior secondary school two (SSS2) students and senior secondary school three (SSS3) students had an equal number of respondents (31.11%).

Table 1: Demographic characteristics of Respondents

Data	ISS	EMSS	NSS	Frequency	Percentage (%)
AGE					
6-8	0	0	0	0	0.00
9-12	7	0	2	9	8.89
13-16	20	22	23	65	73.33
17-20	3	6	4	13	14.44
21-Above	0	2	1	3	3.33
SEX					
Male	12	17	9	38	42.22
Female	18	13	21	52	57.78
CLASS					
SSS1	10	13	11	34	37.78
SSS2	12	7	9	28	31.11
SSS3	8	10	10	28	31.11

Source: Field Work (2019)
Note: (ISS) is Ihiagwa secondary school; (EMSS) is El-Betty Model secondary school and (NSS) is Nekede secondary school.

Table 2 showed the result of respondents' level of awareness and knowledge about wildlife conservation. More than half of the respondents (66.67%) responded that they were not been thought about wildlife conservation and that they do not take part in biodiversity conservation. Then (28.89%) responded that they have heard about the importance of wildlife conservation but believe it was meant for adults to practice. In other words, they know but were not practicing it. This may be as a result of lack of knowledge on wildlife conservation policy or penalty attached to wildlife destruction. This contributes to the reason why they can catch birds and kill indiscriminately without fear. On the other hand, a very small percentage of respondents (3.33%) were not aware of or heard about wildlife conservation before. This group belongs to those that can kill wildlife even in public places. Their responses declared that it is likely for people to be committing an offense such as killing or maltreating wildlife without knowing that it is wrong. Experimental birds and urban wildlife have been caught severally and killed without any reason. This is why it is important to use different means of awareness creation tools and channels to instruct the public on the importance of wildlife conservation. The lowest percentage of the respondents (1.11%), unfortunately, thought that it is their right to kill wildlife. Despite having the knowledge about conservation but at the same time, it is their heritage. These groups of people may not stop poaching even at gunpoint.

Table 2: Awareness/knowledge and practicing of wildlife conservation

Response	ISS	EMSS	NSS	TOTAL	PER (%)
Unaware of wildlife conservation	14	22	24	60	66.67
Aware but not practicing	14	06	06	26	28.89
Not aware but practice	01	02	00	03	03.33
Not aware, not practice	01	00	00	01	01.11

Note: (ISS) is Ihiagwa secondary school; **(EMSS)** is El-Betty Model secondary school and **(NSS)** is Nekede secondary school.

Table 3 presented the results obtained from the above question about the reason for the decrease of the wild animal population, which was satisfactory. The highest number of respondents (82.22%) revealed that wild animal populations are decreasing because of daily hunting. This is caused by unemployment even among graduates. Even the employed ones are being sacked every month. So the struggle for survival was laid on the indiscriminate killing of young and adult animals for food. A smaller percentage of the respondents (7.78%) said that wildlife is decreasing because of habitat destruction. They insisted that modern technologies and urban construction have contributed to many wildlife habitat. This is true because individuals, groups, and organizations keep on buying land and clearing forests for one project or another. New companies are being built where the forest was before. This practice of development can destroy wildlife habitats and also brings about a decrease in the wildlife population. Coincidentally, (7.78%) of the

Respondents said that the animals are not reproducing faster as they should. This statement might be a result of some factors that disturbs wildlife. This is in line with the report of (Ijeomah, *et al*, 2005) who in their study revealed that crocodile finds it difficult to reproduce where there is noise pollution. The smallest number of respondents (2.22%) said that wild animals are decreasing because of climate change. They reported that the change in weather patterns like hot climate, seasonal differences may made the animals uncomfortable in their habitat. This type of disturbance, according to (Koenig *et al*, 2002) can bring about diurnal migration. The animals can change position at any time, either within the habitat or outside of it.

Table 3: Reason for the decrease in wildlife population

Response	ISS	EMSS	NSS	TOTAL	PER (%)
Daily hunting	22	27	25	74	82.22
Habitat destruction	04	00	03	07	07.78
Low reproduction	01	00	01	02	02.22
Climate change	03	03	01	07	07.78

Note: (ISS) is Ihiagwa secondary school; **(EMSS)** is El-Betty Model secondary school and **(NSS)** is Nekede secondary school.

Table 4 showed the result of the solutions for poaching which revealed that more than half of the respondents (63.33%) stated that a ban should be placed on the illegal felling of trees and killing of wild animals. They believed that this will help to conserve plants and wild animals. On the other hand, (24.44%) of the respondents mentioned that money should be collected from the offenders for illegal felling of trees. This may be a good strategy to reduce the illegal destruction of biodiversity. Ijeoma *et al*, 2005 revealed that said that National wildlife law in Nigeria is outdated. This means that there is no serious penalty for killing wildlife and that is one of the reasons why people destroy biodiversity.

Some of the respondents (7.78%) stated that the solution to wildlife conservation is to re-plant the number of trees that were felled and practice domestication in the case of wildlife, while the smallest number of them (4.44%) answered that more forest should be established to achieve sustainable biodiversity conservation.

Table 4: What are the solutions for poaching?

Note: (ISS) is Ihiagwa secondary school; **(EMSS)** is El-Betty Model secondary school and **(NSS)** is Nekede secondary school.

Response	ISS	EMSS	NSS	TOTAL	PER (%)
Ban on poaching	14	21	22	57	63.33
Payment of fine	10	04	08	22	24.44
Re-afforestation	03	04	00	07	07.78
Afforestation	03	01	00	04	04.44

Source: Field Work (2019)
Note: (ISS) is Ihiagwa secondary school; **(EMSS)** is El-Betty Model secondary school and **(NSS)** is Nekede secondary school.

Table 5 is the results of some of the questions asked to the respondents that were in form of a Likert scale which varies from {Strongly Agree (SA), Agree (A), Disagree (D), and Strongly Disagree (SD)}. The highest number (63.33%) of the respondents strongly agreed that over pollution of the environment can bring about the extinction of wild animals, (28.89%) agreed, (7.78%) disagreed while (11.11%) strongly disagree. This agrees with the previous work of Reznick and Ghalamber, 2001, that pollution like noise, water, and air can affect wildlife. Surprisingly, (51.11%) of respondents strongly agreed that it is not wrong to hunt wild animals for food, (23.33%) also agreed (12.22%) disagreed while (13.33%) strongly disagreed. The smallest number (18.89%) of respondents strongly agreed that participation in afforestation programs is a mere waste of time and energy, (21.11%) agreed, (28.89%) disagreed while the highest number (31.11%) respondents strongly disagreed.

Table 5: Conservation awareness questions

Response	ISS	EMSS	NSS	Frequency	Percentage
Over Pollution of Environment Can Bring About Extinction of Wild Animals					
Strongly Agree	17	23	17	57	63.33
Agree	7	7	9	23	25.56
Disagree	3	0	1	4	4.44
Strong Disagree	3	0	3	6	6.67
It is not wrong to hunt animals for food					
Strongly Agree	18	17	11	46	51.11
Agree	8	4	9	21	23.33
Disagree	3	4	4	11	12.22
Strong Disagree	1	5	6	12	13.33
Participation in Afforestation programs is a mere waste of time and energy					
Strongly Agree	3	3	11	17	18.89
Agree	4	6	9	19	21.11
Disagree	13	9	4	26	28.89
Strong Disagree	10	12	6	28	31.11

Source: Field Work (2019)
Note: (ISS) is Ihiagwa secondary school; **(EMSS)** is El-Betty Model secondary school and **(NSS)** is Nekede secondary school.

CONCLUSION

This study has shown that secondary school students are not fully aware of wildlife conservation and its practice. It calls for more effort to inculcate into future generations the need to preserve our biodiversity. It is also imperative that Nigeria take more decisive action and rise to the challenge of creating more awareness in conserving its wild fauna resources if there will be a future where her children will live in harmony with nature. Despite the numerous benefits man derives from wildlife resources, reckless exploitation of the species remained unceasing and unabated. Human activities such as bush burning, damming of rivers, draining of swamps, environmental pollution, hunting, and poaching have continued to threaten wildlife existence in the Nigerian environment. Consequently, many animals are facing extinction and are classified either as threatened or endangered species according to the world conservation society. Conservation goals and objectives in the country's national policy ought to be given more attention as concerned

NGOs continued to implore and support the government in integrating them. As man is the chief culprit in interference with the natural environment, the responsibility is equally on him for sustainable management and use of the resources nature has made available.

RECOMMENDATION

This study recommends that conservation awareness education should be incorporated into the secondary school curriculum, to start on time to teach young children their responsibilities regarding wildlife conservation. Also to create conservation awareness in all levels of education, through outreach, posters, news broadcast, interviews, and public lectures. This will enhance the importance of wildlife and reduce illegal activities by future generations. Interestingly, proper wildlife conservation will be achieved in Nigeria if the government focuses on achieving food security through the mass production of crops through commercial agriculture.

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Impact of Different Land Uses on Soil Erodibility Assessed using selected Indices in Awka, Southeastern Nigeria

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K E Y W O R D S

Erodibility,
Grassland,
Impact,
Indices,
Landuse

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A B S T R A C T

Land use is considered to be one of the drivers of many processes of environmental change that includes erosion. The impact of land use on soil erodibility were evaluated at Nnamdi Azikiwe University, Awka. Five land use types (forest land, rice farm, cassava farm, grassland and plantain farm) were used for this study. Soil samples were collected from each of the land use in five (5) replicates at 0-20 cm depth. Collected samples were subjected to laboratory analysis. Selected erodibility indices such as dispersion ratio (DR), clay dispersion index (CDI), clay flocculation index (CFI), clay ratio (CR) were used to assess land use impact on soil erodibility. Results obtained were subjected to data analysis using analysis of variance and Pearson's correlation analysis. Soils of the studied area were generally acidic and had a sandy loam texture. Bulk density and aggregate stability were higher under rice farm. Moisture holding capacity was higher under grassland and lower under plantain farm. Higher organic carbon, CEC and available phosphorus were obtained under grassland when compared to other land use types. The higher the dispersion ratio (DR) and clay dispersion index (CDI), the higher the ability of the soil to disperse while the higher the clay flocculation index (CFI), the better aggregated the soil becomes. Higher CFI was obtained under cassava farm while plantain farm had the highest CR value. This study encourages land use practices that improve the physical and chemical conditions of the soil so as to reduce susceptibility to erosion.

INTRODUCTION

Soil erodibility is an estimate of the ability of soil to resist erosion based on the physical characteristics of each soil. Generally, soils with faster infiltration rates, higher levels of organic matter and improved structure have a greater resistance to erosion (Dexter, 2004). Erodibility is the resistance of the soil to both detachment and transport (Emeka, 2014) and it varies with soil textures, aggregates, stability, shear strength, soil structures, infiltration capacity, soil depth, bulk density, soil organic matter and chemical constituents. The erodibility of soil is a function of land use as it affects the stability of soil aggregates. Inherent soil properties could influence the behaviour of soils therefore understanding of soil properties is important in determining the use to which a soil may be put (Amusan *et al.*, 2006). The physical properties of soil deteriorates with change in land use especially from forest to arable land ; however research has shown that land use influence structural stability more than intrinsic soil properties and that percolation stability of soil increased with increase in soil organic matter content (Mbagwu and Auerswald, 1999). Land use is defined as the arrangements, activities and inputs people undertake in a certain land cover type to produce, change or maintain it (Ufot *et al.*, 2016). Changes in land-use due to urbanization, agricultural expansion, deforestation, and monoculture productions have led to an accelerated and spatial increase in erosion. Therefore, understanding the effects of land use system on soil attributes is vital for enhancing food security and environmental quality (Igwe and Obalum, 2013). Dispersion ratio, clay dispersion index, clay flocculation index have been reported to be good indices for estimating soil erodibility based on soil characteristics (Oguike and Mbagwu, 2009; Igwe, 2005) and are very important in regulating soil losses and soil quality (Kalhorw *et al*., 2017).

MATERIALS AND METHODS

Site Description

The study was conducted in Nnamdi Azikiwe University, Awka Southeastern- Nigeria. It is located in Awka South Local Government Area of Anambra State and lies within latitude $06^{0}12^{1}$N and $06^{0}25^{1}$N and longitudes $07°7^{1}$E and $07^{0}11^{1}$E. The geologicaI formation that underlies Awka are the Imo shale and Ameki Formation. The soils are continuously cultivated with cassava, yam, maize and rice. Most of the original rainforest vegetation have been lost due to clearing and human settlement. Awka has rainy and harmattan climatic conditions. The cumulative annual mean rainfall is about 2553.07mm (Omoja *et al.,* 2021). It has an average mean temperature of about 28 ^{o}C and an average relative humidity of about 84 %.

History and features of the land use types studied

The study sites comprised of five (5) land-use types which include Rice farm (RF), Grassland (GL), Plantain plantation (PP) and Forested land (FL). The rice farm lies within latitude $6°15^{1}$N and longitude $7°07^{1}$E; it has been in use for over 6yrs for cultivation of rice. Cassava Farm lies within latitude $6°\ 15^{1}$N and longitude $7°06^{1}$E; this farm has been in use for over 4yrs for cultivation of cassava. Grassland lies within latitude $6°\ 14^{1}$N and longitude of $7°07^{1}$E. Species of grasses found there were Oat grass, thatching grass, Burgrass, and Corngrass. Plantain farm lies within latitude 6° 211 N and longitude 7° 071 E; this has been in use for plantain farming over 4 yrs. Forested Land is at the mapped site of Forestry and Wildlife Department; it lies within latitude $6°22^{1}$N and longitude $7°07^{1}$E. The forest land had been under forest management for more than 20yrs. Some trees found in this forest area includes; Bamboo (*Bambusa vulgaris*), palm trees (*Elaeis guineensis*) and velvet fruit (*Dialium guineense*).

Soil sampling and handling

Prior to soil sampling a reconnaissance visit was made to identify the land use types. Soil samples were collected in Five (5) replicates from each of the land use type at 0 -20cm soil depth and this was used for chemical analysis. Core samplers of about 5cm was used to collect soil samples undisturbed and was used for physical analysis. Collected soil samples were bagged, labelled accordingly and air dried for onward laboratory analysis.

Laboratory analysis

The following Soil physical and chemical analysis were carried out.

i. Particle Size Distribution: The hydrometer method as described by Gee and Or 2002 was used to determine the particle size distribution of the samples. Textural class was determined using textural triangle.

ii. Soil Bulk Density: The bulk density was determined by core method as described by Grossman and Reinsch (2002).

iii. Moisture content: The gravimetric method of determination of soil moisture content was used and calculated using the equation

$$\text{GMC} = \frac{W2 - W3}{W3 - W1} \times 100 \qquad \dots\dots\dots\dots\dots (1)$$

Where Mc is the Moisture content, W1 is the Weight of container, W2 is the Weight of container and sample and W3 is the Weight after oven drying.

iv. Aggregate Stability: Soil Aggregate stability was determined using wet sieving method of Kemper and Rosenau (1986).

v. Soil pH: Soil pH was measured electrometrically by glass electrode in pH meter in both KCI (1 N) and distilled water suspension using a soil: liquid ratio of 1: 2.5 (International Institute for Tropical Agriculture, 1979)

vi. Soil organic carbon will be determined using the wet dichromate oxidation method of Walkley and Black (1934). Organic matter will be calculated by multiplying the value of organic carbon by a factor of 1.724 (Van Bemmelen factor).

vii. Total Nitrogen (TN): This was determined by the Kjeldahl digestion method according to Jackson (1965).

viii. Available phosphorus: This was determined using Bray II method according to Olsen and Sommer, (1990).

ix. Cation Exchange Capacity (CEC): This was determined by 1N ammonium acetate extraction method.

Determination of Erodibility Indices: Soil erodibility indices was evaluated by the method

of Dong *et al*. (1983) as computed in the following formula:

(i) Dispersion Ratio (DR) = $\dfrac{\%\ \text{Silt} + \%\ \text{clay in water}}{\%\ \text{Silt} + \%\ \text{clay in calgon}}$

(ii) Clay Flocculation Index (CFI) = $\dfrac{\%\ \text{clay (calgon)} - \%\ \text{clay in water}}{\%\ \text{clay in calgon}} \times 100$

(iii) Clay Dispersion Index (CDI) = $\dfrac{\%\ \text{clay in water}}{\%\ \text{clay in calgon}} \times 100$

(iv) Clay Ratio = $\dfrac{\%\ \text{Sand} + \%\ \text{Silt in calgon}}{\%\ \text{clay in calgon}}$

Statistical analysis

Data collected was subjected to analysis of Variance using GENSTAT software (12th edition) to compare the impact of land use on soil erodibility. Significant difference between the means was separated using Duncan's multiple range test at 5% probability level. Pearson's correlation analysis was used to determine the relationship between selected indices and soil properties.

RESULTS AND DISCUSSION

Physical properties of soil under different land uses.

The results of the physical properties of soil under different land uses are shown in table 1. The particle size distribution showed that rice farm had the highest mean sand content of 723 g/kg while forest land had the lowest mean sand content of 591g/kg. Forest land had the highest mean silt content of 320g/kg while cassava had the lowest mean silt content of 150 g/kg. Cassava farm had the highest mean clay content of 164 g/kg while plantain farm had the lowest mean clay content of 64 g/kg. Sand particle dominated the soils of the area and belongs to sandy loam textural class. Higher sand contents obtained in soils of different land uses suggests low CEC, leaching of nutrients and can encourage soil erodibility on exposure to high rainfall. Plantain farm had the lowest mean soil BD of 1.30g/cm³ while Rice farm had the highest mean soil BD of 1.94g/cm³. The higher BD obtained in rice farm could be due to the impact of repeated tillage operations over a period of time. Grassland had higher water holding capacity of 11.67 when compared to other land uses. The aggregate stability of soils of the different land uses ranged from 0.35%-0.42%. Aggregate stability of soils of the land uses studied were generally low and could be due to low soil organic matter and sandiness of the area. According to Kay *et al*., (1999) a level of soil organic carbon of 2.0% to 2.5% is considered necessary to maintain good aggregate stability and is considered to deteriorate rapidly when SOC falls below 1.2% to 1.5%.

Table 1: Physical Properties of Soil under different land use types

Land Use	Depth (0-20cm)	B.D g/cm^3	M.C%	Aggregate stability	SAND g/kg	SILT g/kg	CLAY g/kg	Textural Class
Forest Land (RF)		1.93^b	9.23^a	0.37^a	591^a	320^b	79^a	SL
Cassava Farm (CF)		1.75^b	9.12^a	0.41^a	687^a	150^a	164^b	SL
Grassland (GL)		1.74^b	11.67^b	0.35^a	654^a	280^b	70^a	SL
Plantain Plantation (PP)		1.30^a	9.09^a	0.38^a	652^a	280^b	64^a	SL
Rice Farm (RF)		1.94^b	9.90^{ab}	0.42^a	723^a	180^a	93^{ab}	SL

Note: B.D= Bulk density, M.C= moisture content

Chemical properties of soils under different land uses

Soil pH was generally acidic and ranged from 4.50 – 5.83. However, the acidity varied amongst the different land use types; the acidic nature of the soils as observed was more a reflection of the nature of the parent material (coarse textured, strongly leached, low fertility) than the effect of land use. The results of this study corroborates with the studies of (Opara-Nadi *et al*., 2010, Nwosu *et al*., *2016*) that reported similar results. There were 0.69, 0.62, 1.32, 0.81 and 0.95 of organic carbon obtained respectively in forest land, cassava farm, grassland, rice farm and plantain farm. Grassland had the highest organic carbon content of 1.32% while cassava farm had the lowest organic carbon content of 0.62%. Organic matter content is used to judge soil quality and degradation. According to Pieri (1991); critical levels of SOM Index less than 5% shows loss of soil structure and susceptibility to erosion, 5% - 7% shows unstable structure and risk of soil degradation, when greater than 9%, it shows stable structure. Results obtained from the land use types studied showed the susceptibility of the soil to erosion. Total nitrogen content as observed in the soils of the area studied ranged from 0.05%-0.11% and are generally low; this could partly be attributed to the predominantly sandy texture of the soil as well as an indication of nutrient loss at the epipedon as suggested by Nwosu *et al., (*2020). The total nitrogen content in soils of the land use types studied were below the critical value of 0.15% for soils of Nigeria as revealed by Chude *et al.,* (2011). Soils under grassland had the highest CEC mean value of 6.16 cmol/kg while soils under plantain farm had the lowest CEC mean value of 5.11 cmol/kg. Landon (1991) rated CEC value of >40 cmol/kg as very high concentration, 25-40 cmol/kg as high , 15-25 cmol/kg as moderate ,5-15 cmol/kg as low and <5 cmol/kg as very low. The result showed that forest land, cassava farm, grassland, plantain farm and rice farm had 1.87 mgkg-1, 1.22 mgkg-1, 4.45 mgkg-1, 1.55 mgkg-1 and 1.83 mgkg-1 of available phosphorus respectively. Highest value of available phosphorus was obtained in grassland while the lowest value was obtained in cassava farm.

Table 2: Chemical properties of soils under different land uses

N o t e : O .

Land Use	**Depth (0-20cm)**	**pH (H_2O)**	**O.C (%)**	**T.N (%)**	**CECEC(cmol/kg)**	**Avail p (mgkg-1)**
Forest Land (RF)		4.50^a	0.69^a	0.06^a	5.78^a	1.87^a
Cassava Farm (CF)		5.68^c	0.62^a	0.05^a	5.15^a	1.22^a
Grassland (GL)		4.71^{ab}	1.32^b	0.11^b	6.07^a	4.45^b
Plantain Plantation (PP)		5.83^c	0.81^a	0.07^a	5.11^a	1.55^a
Rice Farm (RF)		5.28^{bc}	0.95^a	0.08^a	6.16^a	1.83^a

CO.C= organic carbon, T.N= Total Nitrogen, C.E.C= Cation exchange capacity

Selected erodibility indices under different land uses

Results of soil erodibility under land use types are shown in table 3. Highest DR mean value of 0.64% was obtained under Plantain farm while cassava farm recorded the lowest with mean value of 0.37%. Cassava farm had the highest CFI value of 51.11% while plantain farm had thethe lowest CFI value of 16.14%. Soils high in CFI are well aggregated and will not easily disperse in water. Highest CDI mean value of 83.86% was obtained under plantain farm while the lowest was obtained under cassava farm. Soils with high DR and CDI are known to be structurally weak and can easily erode. Also, the high value of DR with low CFI indicates low resistance of soil aggregates to the breakdown by water. Clay ratio measures the amount of binding due to clay. Highest CR mean value of 15.49% was obtained under Plantain farm while the lowest mean CR value was obtained under cassava farm. Higher CR indicates lower binding influence due to clay and therefore higher susceptibility to erosion.

Table 3: Selected erodibility indices under different land use types

Land Use	DR%	CFI%	CDI%	CR%
Forest Land (RF)	0.55ab	28.53a	71.47a	13.05a
Cassava Farm (CF)	0.37a	51.11a	48.89a	8.26 a
Grassland (GL)	0.45ab	17.76 a	82.24 a	15.21 a
Plantain Farm (PF)	0.64b	16.14 a	83.86 a	15.49 a
Rice Farm (RF)	0.42ab	37.07 a	62.93 a	11.41 a

Note: DR= dispersion ratio; CDI= clay dispersion index; CFI= clay flocculation index, CR=clay ratio.

Relationship between erodibility indices and selected soil properties

The results in table 4 showed that CR and CDI had a significant positive correlation(r= 0.436*, r=0.431*) with sand. DR, CDI and CR correlated negatively (r= -0.403*, r=-0.805*, r=-0.810*) with clay while CFI had a significant positive correlation (r=-0.805*) with clay. CFI correlated positively(r = 0.427* r = 0.056) with BD and OC. The sign of the coefficient indicates the direction of the relationship. If the coefficient is positive, it means both variables tend to increase or decrease together whereas when negative it shows that one variable tends to increase as the other decreases.

Table 4. The relationship between erodibility indices and selected soil properties

Soil properties	DR	CFI	CDI	CR
Sand(g/kg)	0.121	-0.431*	0.431*	0.436*
Clay(g/kg)	-0.403*	0.805*	-0.805*	-0.810*
Silt(g/kg)	0.18	-0.16	0.16	0.16
B.D (g/cm3)	-0.11	0.427*	-0.427*	-0.414*
pH (H_2O)	-0.196	0.292	-0.292	-0.298
CEC(cmol/kg)	-0.039	0.007	-0.007	0.001
O.C (%)	-0.244	0.056	-0.056	-0.042

CEC= Cation exchange capacity; OC= organic carbon; DR= dispersion ratio; CDI= clay dispersion index; CFI= clay flocculation index, CR=clay ratio.

CONCLUSION

Based on the study; land use influenced some soil properties and erodibility. Bulk density and aggregate stability were higher under rice farm when compared to other land use types. Organic carbon was more under grassland and lower under cassava farm. High CFI indicates the level of aggregation of the soil and was in the order CF>RF>FL>GL>PP while high CR indicates high susceptibility of soil to erosion. CR of soils under different land uses were in the order PP>GL>FL>RF>CF. soils of the studied area are susceptible to erosion. Therefore, it is important that management practices and measures that incorporates and retains organic matter especially within the top soil should be practiced to prevent erosion.

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Correlating Forest Cover Loss with Land Surface Temperatures of Nnamdi Azikiwe University, Awka using Remote Sensing Methods

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K E Y W O R D S

Forest cover,
Forest loss
Land surface temperature
Remote sensing
UNIZIK

A B S T R A C T

Human pressures, combined with changing hydrology and land resources, have a distinct effect on the carbon chain and ecosystem resilience. The increase in urban areas contributes significantly to the loss of vegetation cover (VC), which accelerates carbon emissions, increasing land surface temperature (LST) and global warming. This study used remote sensing and GIS techniques to estimate the Land Use/Land Cover (LU/LC) changes by focusing on VC loss and its impact on LST and carbon emissions in Nnamdi Azikiwe University during 2001-2021. The study's findings confirmed an reduction of VC of about -39% from 2001- 2011 with around 27.2% increase of vegetation cover loss, and corresponding LST rise from 22˚C to 35˚C. The trends were continuous, with a decrease in VC loss by -30% during 2011–2021, contributing 26˚C– 42˚C LST rise in the study area. Results indicate that the massive amount of carbon attracted the sun's rays due to the VC loss and raising the surface temperature by 20˚C since 2001, which directly contributing to global warming. Thus, to mitigate climate hazards, efforts to slow urbanization to reduce pollution gateways and increase carbon sinks through afforestation will significantly contribute to protecting humanity from global warming

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INTRODUCTION

Nowadays, global warming has become one of the most important environmental challenges facing humanity. Presently, many directions have been opened in the study of the relationship between forest resources and land surface temperature (LST).

Chen *et al*., (2022) expresses that rapid urbanization has led to the evolution of urban landscape patterns and processes that result to changes in the types of urban surface cover, and which in turn lead to further changes in the thermodynamic properties of urban surfaces that give rise to urban heat island (UHI) effect and other ecological consequences. In Nnamdi Azikiwe University (NAU), where urbanization is at its peak, NAU is facing rapid urbanization. The three decades' campus-level study by Ogbodo, *et al*., (2020) discovers that unplanned urban expansion contributes significantly to forest cover changes. NAU has witnessed remarkable expansion, growth and developmental activities such as building, road construction and many other anthropogenic activities since its inception in 1992, which has led to increased land consumption and a modification and alterations in the status of her land use over time. Unplanned transition of LULC classes could affect ecological sustainability and an increase of LST within the Awka campus of Nnamdi Azikiwe University.

Thus, the main task of this study was to assess the impact of urban heat island within the Awka campus of Nnamdi Azikiwe University by mapping the land surface temperature using multi-temporal satellite remote sensed images based on the various land cover types available within the University. Remote sensing approach has proven capability to modelling land surface temperatures (LST) from LULC within an ecological landscape (Hart and Sailor, 2009). Combining RS and GIS technology makes it easier to analyze, monitor, and simulate LULC and LST variations (Niyogi, 2019). Furthermore, due to the scientific progress of statistical algorithms, which are applied in remotely sensed data, spatiotemporal evaluation of LULC and LST dynamics have provided significant smart solutions of the temperature increasing problems due to haphazard land cover change (Celik,2019). Thermal remote sensing technology is to measure the urban heat island (UHI) which is considered as an effective approach to evaluate the inauspicious impacts of human activities on local climate over the last couple of decades (Naim and Kafy, 2021). In the light of the above, the goal of this study is to investigate a two-decade loss of forest cover and its impacts on LST (2001 to 2021) using Landsat satellite remote sensing approach in Nnamdi Azikiwe University Awka towards contributing to attaining sustainable university campus in line with the Paris Climate Agreement in Nigeria.

METHODOLOGY

i. Study Area: This study was conducted at Nnamdi Azikiwe University (NAU) in Awka, Anambra state. NAU is situated on the geographic coordinates of 6°14’38.4”N and 7°07’18.7”E. The temperature in Awka is generally 27–30oC between May and January but rises to 32–34°C between February and April, with the last few months of the dry season marked by intense heat (Ogbodo *et al*., 2020).

ii. Remote sensing data used in this study: Two multi-sensor Landsat imagery (i.e. Landsat 7 ETM and Landsat8 OLI) were downloaded from https://earthexplorer.usgs.gov and analyzed in this study. The above-mentioned data each has 30m spatial resolution. The Landsat satellite imageries were taken during the dry seasons of Years: 2001, 2011, and 2021.

iii. Ground-Truthing Data for Validation: To validate the classified maps, ground-truth (reference) data together with their Global Positioning System (GPS) coordinates were obtained from Google Earth in ascertaining how many ground truth pixels are correctly classified. Therefore, fifty (50) regions of interest (AOI) were purposefully sampled per land cover class in the study area (Lillesand *et al*., 2008).

iv. Estimation of Normalized Differential Vegetation Index (NDVI): For this study, NDVI values are grouped/ stratified into five classes using the raster calculator. The resolutions of the NDVI values were compared with standard NDVI values to determine the loss of VC over the study area for the years 2001, 2011 and 2021. The class of NDVI was estimated to identify the concentration of LST rise in different categories of VC classes. NDVI values were calculated using Equation 1:

$$NDVI = \frac{(NIR-R)}{(NIR+R)} \qquad (1)$$

v. Estimation of Land Surface Temperature (LST): Land Surface Temperature which measures the thermal radiance from the land surface where the incoming solar energy interacts with and heats the ground was estimated using Landsat thermal band images from 2001, 2011, and 2021 which are band 6 (2001 and 2011) and band 10 (2021). The LST for this study was calculated using the raster calculator in Arc GIS 10.3. Landsat sensors accumulate thermal data and Digital Numbers (DN and these DN were converted to LST with four steps process illustrated below (Kafy *et al*., 2021; Celik *et al*., 2019; Connors *et al*., 2013; Pal and Ziaul, 2017).

vi. Estimation of Land Cover

The satellite images were classified into five land cover classes, namely built-up area, forest, farm land, pave land and bare surfaces in the study area. The aforementioned land cover classes were made based on spectral characteristics of the at image analysis (Phiri and Morgenroth, 2017). Next, supervised classification was done by following three stages that included training data sets, classification and output. Training samples were taken for each land cover type that was identified on the supervised classification output. The classification was done by using maximum likelihood classifier (Shivakumar and Rajashekararadhya, (2018).

RESULTS

Land Cover Classification Analysis

In the supervised classification, false color composite of the image was created for the classification to be done, bands 7, 4, 2 for Landsat 7 images and 7, 5, 3 for Landsat 8 images. The data below in table 2 shows the percentages of change detected in 2001 over 2021, which are; built-up areas (67.39%), farm lands (62.77%) and reduction in forest (-55.50%), bare lands (-52.94%) as a result urbanization, agriculture, industrialization etc.

Analyzing the intensity of vegetation coverage from 2001 - 2021

The health status of Vegetation Cover in the study area for different time intervals is estimated using NDVI distribution analysis illustrated in figure 6 where the green areas indicates vegetation and the yellow and red areas indicates non- vegetation In the supervised classification, false color composite of the image was created for the classification to be done, bands 7, 4, 2 for Landsat 7 images and 7, 5, 3 for Landsat 8 images. The data below in table 2 shows the percentages of change detected in 2001 over 2021, which are; built-up areas (67.39%), farm lands (62.77%) and reduction in forest (-55.50%), bare lands (-52.94%) as a result urbanization, agriculture, industrialization etc. Figure 2 shows the land cover map for the period under investigation while figure 3 shows the graphical representation of the land covers distribution of the study years.

Table 4: NDVI values showing tree loss in the study period

Study year	2001	2011	2021
NDVI values	0.56	0.52	0.34

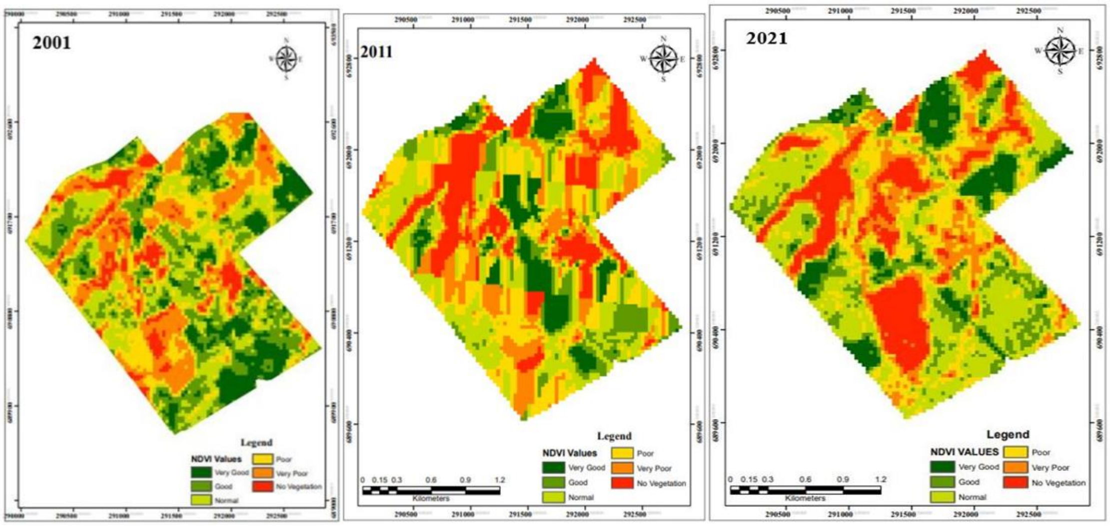

Figure 1: Map of the landcover types showing tree cover in green colour

Variations of LST – 2001, 2011 and 2021

Spatial distribution map in Figure 1 indicates the lowest and the highest LST values range that vary across the three selected periods which are; 22˚C - 33˚C for the year 2001, which increased to 26˚C to 35˚C in 2011 and further increased to 28˚C to 42˚C in the year 2021.

DISCUSSION

The Supervised classification scheme which was used and identified on the image is five land cover classes: Built-up Area, Bare Ground, Forest, Farmlands and Pave land. The Raster processing tools on ArcGIS were used for data processing and training samples from the different images were collected using image classification tools on ArcMap and the accuracy was evaluated. After the collection of training samples, the images are classified based on the algorithm specified.

Ogbodo *et al*. (2017) express that expansion of infrastructures is one of the factors that drive deforestation in public universities that are majorly situated within the natural forest part of Southern Nigeria. The results of this study is in agreement to Ogbodo *et al*. (2017) as forest land cover was the major land cover in 2001, but gradually reduced as a result of human induced factors, while built ups continued to increase and gradually became the major land cover in 2021 such as lecture theatres, administrative blocks, student hotels, without corresponding reforestation or afforestation. Furthermore, Igu *et al.,* (2021) expressed that, forest cover is reducing at astronomical scales as a result of a host of anthropogenic activities. Its greatest toll and impact are however seen in tropical landscapes where land use changes arising from agriculture and urbanization (built up areas) are growing in scale. Clearly, forest land cover suffers in the face of industrialization, urbanization, human population increase and infrastructural development; due to the fact that Governments and some individuals are more interested in the immediate economic growth, hence pay little attention to the environmental services that forest vegetation provide. Fiasal *et al.,* (2021), identified that deduction of healthy vegetation cover by impervious surfaces such as buildings and roads accelerates less sensible heat fluxes by replacing robust latent heat fluxes released by Vegetation Cover through evapotranspiration. Pettorelli, (2013) stated that, the health of a forest is mostly determined by how well its vegetation absorbs most of the visible light that hits it, while reflecting a large portion of the near – infrared light. Unhealthy or sparse vegetation reflects more visible light and less near – infrared light. This is line with this study.

While in 2021, it was observed that the forest cover reduced to 18.5%, likewise it's NDVI value to 0.34 and it's LST increased to 28◦C. This is an indication of a loss in the protective function of the forests in the study area, as more solar radiation directly hits the land surface. Such anomalies are expected and inevitable in an area with increasing population and attendant pressures such as the Niger Delta region and much of tropical landscapes (Igu, 2017). The declination of vegetation cover and the increase of non-vegetated areas have intensified this huge increase of LST. This period was characterized by intense deforestation and clearing of land for various developmental projects and agriculture which is made evident by the level of increase in observed bare land and built-up areas which are characterized by vegetal removal and the concomitant decrease in total vegetal cover. This rapid depletion of vegetation cover has a wide range of impacts such as in the reduction of the natural cooling effects of shading and evapotranspiration of plants and shrubs. However, rapid urbanization and reduction in Vegetation Cover are mainly responsible for temperature increase and Urban Heat Island effect.

CONCLUSION AND RECOMMENDATION

Due to urban growth of the university, there have been significant changes in the land cover of the study area such as decrease in the vegetated areas and increase in built up areas. The results of the NDVI values of the study area also showed that forest health declined through the years. A decline in forest health is an indication of forest degradation. The declining forest cover, as well as the NDVI values of the study area corresponded with increasing LST values through the study years. This is an indication of a loss in the protective function of the forests in the study area, as more solar radiation directly hits the land surface. Hence, the study findings confirm that Nnamdi Azikiwe University has been experiencing consistent Vegetation Cover loss since 2001.

In view of the observed trend in Land Cover change and the impact of Land Surface Temperature, the need for tree planting and increased awareness on the impacts of forest conversion/deforestation on our environment and general wellbeing should be emphasized.

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Evaluation of Industrial and Thermal Properties of Mangrove Tree (*Rhizophora racemosa*) Tannin on Variegated Wood Waste

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K E Y W O R D S

Heating time,
Flaming balls,
Tannin,
Thermal capacity,
Wood-waste,

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A B S T R A C T

Poor thermal capacity accompanied with deleterious fumes of nitrogen, sulphur and carbon oxides from sawmill wood wastes has led to its decreased utility as domestic energy alternative with consequent environmental implications during combustion at source. This study was undertaken to assess the effect of red mangrove tannin on the thermal capacity of wood waste as potential industrial material for other wood-based products. Tannin extracted from Rhizophora racemosa (red mangrove) bark with methanol (TBM) and water (TBW) as well as leaves with methanol-water (TLMW) were investigated for pH, specific gravity, viscosity, gelation time, total solid content, stain potential, flash point, cold and warm setting times. These were further employed to produce three (3) single-source tannin flaming balls – TBM, TBW and TLMW as well as composite-source types - TBM+TBW, TBM+TLMW and TBW+TLMW using wood-shavings and dust. Flaming balls were engaged to heat up distilled water for 3, 6, 9, 12 and 15 minutes while temperature attained were recorded respectively. Data collected were analysed using analysis of variance (ANOVA) and significant means separated with Duncan Multiple Range Test (DMRT) at 5% level of probability. The results showed that TBM had highest specific gravity (1.80g/cm^3), pH (7.60) and Viscosity (2.98poise) while the thermal capacity of the wood-waste was composite TBM+TLMW (100.5 ± 0.63^{o}C) >TBM+TBW> TBW+TLMW compared to sole TBM (90.8^{o}C) > TBW > TLMW > CTR (48.1^{o}C) flaming balls. Thus recommends the need of wood-wastes tannin flaming balls as improvement in the energy sector to combat global warming and mitigate climate change in low-income conurbations.

INTRODUCTION

Forest conservation efforts have been significantly threatened by the poor extraction and conversion processes of wood-based industries that has not only given birth to increased traffic in the forest for more exploitation but has also led to abounding generation of wastes to constitute serious environmental menace and pollution in towns and cities. An average of 20-40 tons of wood waste are generated on daily basis as saw dust, particles and chippings from bench mills located in tropical forest communities and towns (MOE, 2017; Babayemi and Dauda, 2010). These local conversion machines have been reported as major causes of waste generation compared to the high precision band-saw equipment with known potential for minimal waste.

However, some of these wood wastes have been engaged in open heating stoves for use in generating energy domestically for cooking (Dubinina *et al.,* 2016; Bourguignon, 2015). The associated gas fumes were reported as detrimental to human health and accounted for a good proportion of respiratory related diseases in the female gender known for preparation of family meals in developing countries (Rinne *et al*, 2006; Khushk, 2005). The poor and prolong heating time as a result of the huge volume required to produce essential heat energy produces large amount of carbon monoxide fumes which have altogether made these sawn wood by-product unappealing. The poor combustion potential of wood waste and dust may not be unconnected with the weak internal bond strength and linkages within the waste particles, particularly in the flakes. Hence at ignition, these often burn singularly as individual fire points with weakened internal bond strength as a result of the disintegration created by the impact of conversion equipment. These poor characteristics therefore result in huge quantities of wood waste employed as domestic heating materials in many rural and semi-urban areas where economic situation does not financially support capacity to acquire kerosene or methane cooking gas.

Consequently, these wastes are abandoned within saw/bench mill premises to initiate eutrophication and many other times burnt at different times of the year to produce varying but significantly offensive oxides of carbon, nitrogen, sulphur, methane and other greenhouse gases (GHGs) as contribution to micro environmental pollution and the global climate change crisis (European Commission, 2014; Khudyakova *et al.*, 2017). The impact of fuel-wood and its allied product on climate change are well documented as singular major contributor to over 30-45% to global warming particularly in developing countries as a result of over reliance on direct use domestically as energy material. Hence, the projected 3.4% increase of the approximately of the 2006 National Population figure connotes further degradation of remnant forest for fuel-wood extraction with commensurate increase in utilization of wood wastes of different origins for domestic energy generation. Therefore, the proper coordination of these wastes through efficient use approach in the light present global climate mitigation practice could go a long way in reducing it as a potential GHGs source.

Tannin have been reported as phenolic natural binders and may therefore induce multiple internal linkages in different grain directions within as well as among the respective particles to sufficiently provide the wood waste external boost unlike the loose individual particles (Basso *et al.*, 2015; Fiori *et al.*, 2013; Gunduz *et al.*, 2011). Hence, its use either exclusively or as combination with urea and phenol formaldehyde resins in the manufacture of interior and exterior wood-based panel products (Von Leyser *et al.*, 2012). This is because its basic characteristics were conformed to the BSI 2020 and ISO 2000 for industrial wood product manufacture. Furthermore, tannin in red mangrove trees species have been reported as the preference to many other wood species for its use in the commercial fish drying scheme because of the attractive colour flavonoids emitted from the wood under increasing thermal conditions (Egwunatum *et al.*, 2022; Nordhaus *et al.*, 2011). It is against this backdrop that tannin from the leaves and bark of red Mangrove (*Rhizophora racemosa*) was characteristically studied as potential industrial materials and source for the improvement of internal bond strength for different wood-wastes in view of efficient thermal qualities with reduced heating time and fume generation to combat global warming *viz-a-viz* climate change.

MATERIALS AND METHODS

Description of study area

The study materials of barks and leaves were collected from the mangrove forest in Koko, Warri North Local Government Area of Delta State, Nigeria. It lies between 6°00′N 5°28′E**.** Koko is the administrative headquarters for the Warri North Local Government Area. The mangrove forest which is particularly rich in *Rhizophora racemosa, R. mucronta* and variety of wildlife species covers an area of over 120 km^2 and provide shoreline protection for the coastal communities while providing valuable forest produce as ropes, fuel-wood, wildlife, timber, etc to sustain livelihood (Aroloye and Numbere, 2020; Mitra, 2020 ;Akanni, *et al*., 2018).

Methods of data collection

The bark was collected from the mid and upper part of the *Rhizophora racemosa* trees by slashing with cutlass and the leaves from the matured lower branches with higher photosynthetic capacity while inside a canoe. The sand was dug from the lower range stilt root region of the mangrove forest.

Experimental materials

The materials used during data collection include

Medium sized hot clay pot; Thermometer; Tannin extract; Variegated wood wastes (sawdust, wood shavings); Heating mantle; Magnetic stirrer; Mortar and pestle; Conical flask; Electric weighing balance; Beaker; Knife ; Water; Consumables as hand gloves, reagents, face shield, etc.

The tannin extraction, industrial characterization of tannin extracts, production of flaming balls and the determination of thermal capacity of the various types of tannin flaming balls were conducted in the Central Chemistry Laboratory of the Faculty of Science, Science Village, Nnamdi Azikiwe University, Awka.

Bark preparation

Fresh barks and leaves were harvested from standing *Rhizophora racemosa* forest in Koko. These were dried under the sun for seven (7) days in order to completely eliminate moisture present in the bark and leaves. Then mechanically grind to produce powder and then stored under room temperature before use in the laboratory.

Tannin extraction

Tannin was extracted from the powdered bark and leaf by method of maceration at 100°C for 130 mins with a solvent-to-bark ratio of 1:4 using methanol and water (50/50) in round bottom flask with a heating mantle as employed by Fuwape *et al.* (1999). These were stirred continuously using a magnetic stirrer until the ground powder samples dissolved in the solvent to allow for sufficient osmosis and diffusion processes.

The solutions were allowed to cool at room temperature for 12 hours after heating and then decanted by filtration into 500 ml beakers using Filter paper No 1 in a funnel. Filtrates were then concentrated for a period of 65 mins and the tannin was allowed to cool at a room temperature before decanted into sample bottles and then stored in refrigerator.

Production of flaming balls

Extracted tannin was used for production of flaming balls. Flaming ball is an improvised fuel source that comprised of sawdust and wood shavings incorporated with liquid tannin using sharp sand as a binder. These were moulded into round balls and then left to dry under the sun for two (2) days. Each flaming ball was constituted of 150 g of wood waste + 100 ml tannin + 25 ml silt-sand. Then, for the production of composite flaming balls, it constituted of 150 g of wood waste + 50 ml of individual composite tannin extract + 25 ml of mangrove silt-sand. These include TBM (Tannin bark extracted with methanol); TBW (Tannin bark extracted with water); TLMW (Tannin leaf extracted with methanol + water); and control (Wood-waste without Tannin).

Experiment with tannin flaming balls

An average of 10 flaming balls per tannin extract type was loaded in aluminium foiled clay-pot upon ignition to generate heat up of 250 ml of water in a beaker from beneath. The heat generated to raise the temperature of water by 1degree Celsius per second ($1^{o}C/s$) at 3, 6, 9, 12 and 15 minutes was estimated as the thermal capacity of tannin flaming balls type. Control treatment consists of wood wastes not impregnated with tannin.

Data analysis

Data collected were analysed using Analysis of Variance (ANOVA) and significant means separated using Duncan Multiple Range Test (DMRT) at 5% level of probability.

RESULTS

Characteristics of extracted tannin

The tannin extract types were compared to the related prescriptions index (RPI) in ISO 2000 for forest product extractives as shown in Table 1. The highest gelation time of 173 mins was recorded by TBW while the lowest time of 135 mins was recorded by TLMW. The TBM recorded a gelation time of 150mins. With respect to viscosity, the TBM record the highest value of 2.98 poise while the TLMW recorded a viscosity of 2.55poise. The least value of 1.86poise was recorded by the TBW. The hydrogen ion [H+] content also ranged as TBM > TBW > TLMW.

The specific gravity was highest for TBM that has a value of 1.80 g/cm^3 while the least (1.31 g/cm^3) was shown by TLMW. The TBW has a value of 1.64 g/cm^3. The total solid was highest for TBM (43.5%) while the least of 28.6% was recorded TLMW. The TBW has a value of 35.4% which also was with the range of ISO 2000 for bark extractives.

Table 1: Industrial characteristics of tannin extract

Tannin Properties	TBM	TBW	TLMW
Gelation time (min)	150.0	173.0	135.0
Viscosity (poise)	2.98	1.86	2.55
pH (H_2O)	7.60	7.20	7.10
Specific gravity (g/cm^3)	1.80	1.64	1.31
Total Solid (%)	43.50	35.40	28.60
Flash point (C)	102.0	180.0	136.0
Stain potential	High	Low	High
Cold setting (min)	30.50	54.30	48.30
Warm setting (min)	90.00	68.00	33.00

Effect of single-source tannin on heating time

The effect of different tannin flaming balls in heating time are shown in Table 2. With respect to 3 min intervals, there were significance difference in the various temperature and heat produced by the different tannin flaming balls ($p < 0.05$). At 180 sec. the highest temperature (30.5ºC) was produced by TBM while the lowest was produced by the control (CTR) at 18.3ºC and there was significance difference. Then, at 360 sec. heating time, the highest temperature was also produced by TBM at 43.6ºC while the lowest temperature was produced by the CTR at 24.5ºC and there was significance difference among them, with regards to the 540 sec. There was significance difference between the heat and temperature produced with TBW flaming balls having the highest temperature of 50.7ºC and also the lowest temperature was produced by the CTR at 26.3ºC, meanwhile at 720 sec; TBW flaming balls also produced the highest temperature of 60.5ºC while TBM and TLMW recorded 50.4ºC and 38.5ºC respectively. The lowest temperature was recorded by the CTR at a temperature of 35.8ºC and there was significance difference.

At the final stage of 900 sec. heating time, there was significance difference in the temperature attained by the various tannin flaming balls. However, there was no significant difference between TBM and TBW flaming balls at temperature of 90.8ºC and 90.3ºC respectively. There was significant difference between TBW, TLMW and the CTR flaming balls.

Table 2: Effect of single source Tannin flaming balls in heating time

		Temp (ºC)		
Time (s)	TBM	TBW	TLMW	CTR (NT)
180.00	30.5^{a}	28.3 ^{b}	20.8 ^{c}	18.3 ^{d}
360.00	43.6^{a}	30.3 ^{b}	25.3 ^{c}	24.5 ^{c}
540.00	48.8 ^{b}	50.7 ^{a}	30.3 ^{c}	26.3 ^{d}
720.00	50.4 ^{b}	60.5 ^{a}	38.5 ^{c}	35.8 ^{d}
900.00	90.8 ^{a}	90.3 ^{b}	52.4 ^{c}	48.1 ^{d}

Mean in the same row with same superscript are not significantly different ($p < 0.05$). Legend: TBM = Tannin bark extracted with methanol; TBW = Tannin bark extracted with water; TLMW = Tannin leaf extracted with methanol + water; CTR (NT) = Wood waste without Tannin (Control)

Effect composite-source tannin flaming balls on heating time

Table 3 showed the effect of combined tannin flaming balls on heating time with respect to 3 min interval heating time. There were significant differences among the various combinations with the TBM + TLMW showing the highest temperature (53.4 ± 0.43ºC) at 3 mins heating time. There was no significant difference between TBM + TBW and TBW + TLMW. There was significance difference among the heating temperature attained, also with TBM + TLMW producing the highest temperature 63.5 ºC at 6 mins. At 9 mins., highest temperature was attained by TBM + TLMW and this also differ significantly from the other combinations (TBM + TBW and TBW + TLMW).

The TBM + TLMW at 12 min recorded the highest temperature of 83.4ºC and was significantly different from TBM + TBW and TBW + TLMW with temperature of 75.3ºC and 58.8ºC respectively. At 15 mins heating time, the highest temperature of 100.5ºC was produced by the TBM + TLMW while TBM + TBW recorded a temperature of 98.1ºC which was also significantly different from TBW + TLMW with a temperature of 67.3ºC.

Table 3: Effect of combined tannin flaming balls on heating time

		Temp (ºC)	
Time (m)	TBM + TBW	TBW + TLMW	TBM + TLMW
3.00	38.5 ± 0.13^{bc}	39.5 ± 0.17^{b}	53.4 ± 0.43 ^{a}
6.00	48.3 ± 0.34^{b}	41.3 ± 0.29^{c}	63.5 ± 0.56 ^{a}
9.00	60.1 ± 0.48^{b}	48.8 ± 0.33^{c}	78.1 ± 0.58^{a}
12.00	75.3 ± 0.55^{b}	58.8 ± 0.46^{c}	83.4 ±0.63^{a}
15.00	98.1 ± 0.73^{b}	67.3± 0.49^{c}	100.5 ± 0.63^{a}

Mean ±standard error in the same row with same superscript are not significantly different ($p > 0.05$). Legend: TBM = Tannin bark extracted with methanol; TBW = Tannin bark extracted with water; TLMW = Tannin leaf extracted with methanol + water.

DISCUSSION

Using the ISO and BSI 2000, the gelation time of all the extracted tannin types were with standard specifications except TBW which was above the range of 120 – 160 mins. Apart from the TBW, the TBM and TLMW recorded when they were in consonance with the IS0 2000 range of 2.00-3.00 poise. In line with the ISO 2000, these were all above the standard value, (> 7.00), which in the neutral pH value at a temperature of 24.5˚C. Apart from TLMW with value of 1.31 g/cm^3, the other tannin extract was with the value of ISO 2000 that ranges from 1.50 – 1.90 g/cm^3. The results revealed that the resultant effect of each tannin extract obtained from Mangrove tree parts using different solvents had impact on the thermal properties and heating times investigated with the flaming balls produced with wood wastes. These flaming balls were of much better thermal capacity compared to raw wood waste as shown in the control without tannin

The TBM-flaming balls had a higher differential temperature (30.5ºC at 180 sec.) because it may have generated the greater amount of heat compared to the control with more or less a bulk and higher pore space materials that were not bonded to produce steady heating process (Bello and Adegbulugbe, 2010). The increase in heating time with the tannin flaming ball of TBM had the highest temperature (43.6ºC) compared to the control which produced the lowest temperature (24.5ºC) probably due to the faster combustion of wood.

The TBW-flaming balls at an increased time of 540 sec. produced the highest temperature of 50.7°C and control possessed the least temperature of 26.3°C. This is majorly because of the presence of a phenolic compound in the flaming ball serving as an adhesive hence improving its thermal capacity agrees with the findings of De Ramos *et al*, (2019) on the flammability qualities of phenolic materials of natural origin. The heating time was increased to 720 sec, the best performing flaming ball at this stage was TBW attaining a temperature of 60.5ºC with the least performing flaming ball being control possessing a temperature of 35.8 ºC. This may be due to the passage of conventional airflow within the loosely packed materials. At 900 sec., the most suitable flaming at this time was TBM it attained a temperature of 90.8ºC while control had the least temperature of 48.1ºC.

The TBM+TLMW combined tannin flaming ball warmed up water to attain the highest temperature among the different heating times to reach the boiling point of water in 15mins. Between TBW+TLMW and TBM+TLMW, the former seem to possess better thermal potential. The thermal potential was TBM+TLMW > TBW+T/W > TBW+TLMW flaming balls throughout the investigated heating period. This superior performance may not be unconnected with the capacity of methanol solvent to have extracted significant quantity as well as quality of tannin from the Mangrove bark compared to water, especially with the poor hydrogen ion content during the various stages of maceration in which osmotic potential occurs to create essential gradient for diffusion process to account for higher yield of tannin before a recourse to simultaneously osmosis-diffusion condition.

Although the TBM+TBW flaming balls performed appropriately, the quantity of tannin yield from the mangrove bark may have resulted in the better binding structure of the balls to enhance thermal properties for reduced heating time compared to the yield from the same weight of mangrove leaves. This is because most forest trees species have greater tannin yield as well as chemical quality from the barks compared to other parts the trees (Bianchi *et al*, 2014; Bianchi *et al*, 2016). The ash content of the various flaming balls varied significantly with the TBM+TLMW type producing the least while the TBW+TLMW the highest. This suggested vividly that the capacity of inherent tanning materials as flammable to induce higher combustion rate for heat generation.

The best performing flaming ball with respect to heating time and temperature was the composite flaming balls produced from tannin extracted with water and tannin extracted with methanol, while the least performance were flaming balls without tannin. Also according to Cesprini *et al.* (2020) organic materials with adhesive characteristics often negatively affects nitrogen oxides and other associate gases production during combustion and emissions. Hence, the flaming balls that have tannin adhesive and phenolic qualities are represent great potential as complimentary thermal product for the efficient and eco-friendly use of wood wastes in the face of global warming and greenhouse gases (GHG) for the mitigation as well as adaptation of rural populace to climate change crisis.

CONCLUSION AND RECOMMENDATION

The findings implicated wood wastes made into flaming balls from *Rhizophora racemosa* tannin bark and leaves extracted with methanol as practicable local products with higher thermal efficiencies for generating heat. Thus, significantly projects the enhanced utilitarian value of the abounding sawmill wood wastes as an abatement strategy for carbon and its associated fumes during source disposal by burning and thereby mitigating global warming and climate change. The study further recommends possible use of tannin extracts for forest floor litters in pursuit of better alternative to fuel-wood for reduced deforestation and degradation.

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Influence of Organic Fertilizers on the Growth Performance of *Eucalyptus torilliana* Seedlings in Nasarawa State, Nigeria

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K E Y W O R D S

Eucalyptus torilliana,
Fertilizer,
Seedlings,
Forest Plantation

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A B S T R A C T

The study aimed to investigate the influence of organic fertilizers on the growth performance of Eucalyptus torilliana seedlings in Nasarawa, Nigeria. Seeds were sown in germination boxes filled with topsoil. At four weeks after germination, 240 seedlings were randomly selected and transplanted into polythene pots filled with 1000 g of top soil. After two weeks of acclimatization, 5 g and 10 g each of poultry manure and cattle dung and 0 g of control were applied as treatments. The experiment was laid out in a completely random design with four treatments. Each treatment consists of 60 experimental pots. Seedling variables such as plant height, number of leaves, leaf area, collar girth, leave length, and leave width were taken fortnightly. The collected data was subjected to an analysis of variance at $p < 0.05$. Results indicated that organic fertilizers significantly ($p < 0.05$) improved the growth of E. torilliana seedlings over the control. The highest mean plant height (9.24±2.29a) was recorded on seedlings treated with poultry manure + cattle dung. Seedlings treated with 10 g of poultry manure produced the greatest mean collar girth (2.05±0.35 a). The best mean number of leaves (9.65±5.62a) was obtained in seedlings treated with poultry manure and cattle dung. There were significant differences ($p < 0.0.5$) in plant height) from week 3 (6.33±1.53f) to week 8 (10.10±1.83a). Poultry manure plus cattle dung performed better than cattle dung, while control performed the least. It is recommended that the application of poultry manure and cattle dung for proper growth of E. torilliana should be encouraged for plantation establishment.

INTRODUCTION

A significant species of tropical tree, Eucalyptus torelliana F. Muell has a wide range of applications and high economic values. The plant, which is tall and evergreen and is a member of the Myrtaceae family, is described as having an irregular crown, grey-green bark, and a persistently scaly, sub-fibrous base (Adeniyi and Ayepola, 2008). It is the second-most widely distributed species of multipurpose woody tree in the world and can reach heights of 30 m while maintaining a straight trunk and good form in a range of environmental conditions (Coffi*et al*., 2012; Pinto *et al*., 2016). It has lovely flowers that are large, creamy white clusters and have numerous valves that are well below the fruit's rim (Adeniyi *et al*., 2006). The different soil types, including loamy soils, sands, and clays, can support the growth of the various tree species. Africa's population pressure has changed the land's cover and urged the growth of woodlots. It has long been recommended to plant exotic tree species such as Eucalyptus to relieve pressure on native forests and woodlands (Boland *et al*., 2006).

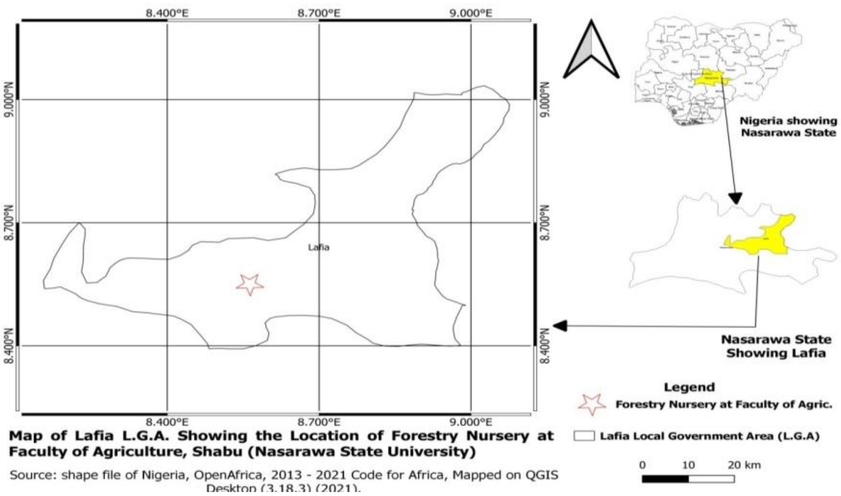
Farmers plant such a tree species because of the rising demand for wood products, the lack of wood on farms, the high rate of biomass production, the ease of cultivation, and the tree's wide range of adaptability (Mekonnen and Aticho, 2011). The tree species can be used for ornamental purposes, shade, shelter, tanning, oil, fuel wood, charcoal, timber, poles, posts, mine props, poly-wood, paper pulp, fiberboard, and as a source of nectar for honey production (Haileab, 2010). Because of its exceptional adaptability, rapid growth, and superior wood properties, Eucalyptus torelliana has been quickly adopted for plantation forestry in more than 100 countries (Pinto *et al*., 2016). The plant is helpful for treating minor aches and pains, food preservation, pharmaceuticals, and pesticides (Ololade and Olawore, 2013).

The tree species is used to treat gastrointestinal problems in Nigeria. A decoction of the leaves is also used to treat other bacterial infections of the respiratory and urinary tract and to treat sore throats (Alian*et al*., 2012; Farah *et al*., 2002). It has been discovered that the complementary application of organic fertilizers can improve yield stability and address any immediate soil nutrient deficits (Aluko *et al*., 2014). The physical, chemical, and biological characteristics of soils are greatly improved by organic materials, which also increase soil fertility and promote plant growth (Walen*et al*., 2001). There is little forestry knowledge that works against the development of this plant species' plantations, despite its potential and economic worth. This investigation was started to determine how organic fertilizers affected the Eucalyptus torilliana seedlings' ability to grow.

MATERIALS AND METHOD

The Study Area

The study was carried out at the Shabu-Lafia campus of Nasarawa State University's Department of Forestry and Wildlife Management in Lafia. The region is situated at an altitude of 177 m above sea level in the Guinea Savannah Zone of North Central Nigeria, between Longitude 080° 35' N and Latitude 080° 33' E. The range of the average monthly maximum temperature is between 35.06°C and 36.40°C, and the average monthly relative humidity is 74.67%, with 168.90mm of rainfall (Jayeoba, 2013). The research area's vegetation is characteristic of Nigeria's Southern Guinea Savannah Zone, which is characterised by tall, short, scattered trees with a grass undergrowth. The people's primary industries are farming, fishing, trading, government service, and hunting.



Map of Lafia L.G.A. Showing the Location of Forestry Nursery at Faculty of Agriculture, Shabu (Nasarawa State University)

Source: shape file of Nigeria, OpenAfrica, 2013 - 2021 Code for Africa, Mapped on QGIS Desktop (3.18.3) (2021).

Experimental design and treatment

At the Federal College of Forestry in Jos, Plateau State, ripe Eucalyptus torelliana seeds were collected. Four days of air drying the seeds in the pods before physically removing them. These seeds were planted in nine topsoil-filled germination boxes. Four treatments were used in the trial, which was set up using a completely randomized design (CRD). At four weeks following germination, 240 seedlings from each germination box were randomly chosen and transplanted into 20 cm 25 cm black polythene pots with 1000g of top soil gathered from Forestry Department teak plantations.Poultry manure and bovine dung were applied to the transplanted seedlings after two weeks of acclimatization (poultry manure 10 g, cattle dung 10 g, poultry manure + cattle dung 5 g, and control 0 g). The ring method was used to provide organic fertilizers to the seedlings that were housed in polythene pots. There are 60 experimental pots used in each treatment.

Data collection and Analysis

After being transplanted, the seedlings were given 14 days to get used to the fertiliser treatments before measurements of their characteristics, such as plant height, leaf count, leaf area, collar girth, leaf length, and leaf width, were obtained every two weeks. A ruler calibrated in centimeters was used to measure the height of the seedlings from the collar to the tip of the apical bud. The collar girth was measured with a vernier calliper. Each seedling used in the experiment had its leaves counted and properly recorded. A meter rule calibrated in centimeters was used to measure the length and width of the leaves. The means of the different treatments were separated using Duncan's Multiple Rang Test at $p < 0.05$ after the gathered data underwent an analysis of variance.

Plate1.*Eucalyptus torilliana* trees

Plate2. *E. torilliana* proceed seeds

Plate 3. *E. torilliana* Seeds sown in germination box

Plate 3. *E. torilliana* seedlings arranged according to treatments

RESULTS

The effect of organic fertilisers on the plant height of E. torilliana seedlings is depicted in Table 1. The results revealed no significant difference between the control and poultry manure ($p > 0.05$), however there were significant differences between the poultry manure and cattle dung ($p < 0.05$). The seedlings treated with poultry manure and cattle dung had the highest mean plant height (9.24±2.29a), while the seedlings treated with cattle dung had the lowest mean plant height (8.56±2.14b), which was obtained from the control.

Table 1: Influence of fertilizers on the plant height of *Eucalyptus torilliana* seedlings (cm)

Treatments	Plant height
Poultry manure + Cattle dung (5.0g + 5.0g)	9.24 ± 2.29^{a}
Control (0g)	7.85 ± 1.89^{c}
Cattle dung (10g)	8.56 ± 2.14^{b}
Poultry manure (10g)	7.88 ± 2.23^{c}
Mean	8.38±2.22

Mean on the same row with same alphabet are not significantly different at 0.05 levels; ns=not significant.

The results in table 2 showed that seedlings treated with poultry manure had the highest mean collar girth (2.05±0.35a), whereas seedlings treated with poultry manure+cattle dung had the lowest mean collar girth (1.88±0.36c). The outcomes also confirmed no changes between seedlings treated with cattle manure and the control ($p > 0.05$).

Table 2: Influence of fertilizers on the Collar Girthof *Eucalyptus torilliana* seedlings (mm)

Treatments	Collar girth
Poultry manure + Cattle dung (5.0g + 5.0g)	1.88 ± 0.36^{c}
Control (0g)	1.97 ± 0.31^{b}
Cattle dung (10g)	1.96 ± 0.40^{b}
Poultry manure (10g)	2.05 ± 0.35^{a}
Mean	1.97±0.36

Mean on the same row with same alphabet are not significantly different at 0.05 levels; ns=not significant.

The findings in table 3 showed that there were significant differences in the average number of leaves ($p < 0.05$). The seedlings treated with poultry manure + cattle dung had the highest mean number of leaves (9.65±5.62a), whereas the seedlings treated with cattle dung had the lowest mean number (7.51±3.48). The outcomes similarly revealed no differences between seedlings treated with poultry manure and those treated with cow dung ($p > 0.05$).

Table 3: Influence of fertilizers on the Number of leaves of*Eucalyptustorilliana* seedlings

Treatments	**No. of leaf**
Poultry manure + Cattle dung	9.65±5.62[a]
Control	9.09±2.79[b]
Cattle dung	7.51±3.48[c]
Poultry manure	7.60±2.66[c]
Mean	8.46±3.93

Mean on the same row with same alphabet are not significantly different at 0.05 levels; ns=not significant.

Table 4 displays the impact of fertilizers on the E. torilliana seedlings' leaf length. The seedlings treated with poultry manure + cattle dung had the highest mean leave length (4.79±1.39a), followed by the seedlings treated with cattle dung (4.49±1.37b), and the seedlings treated with poultry manure had the lowest mean leave length (4.71±1.59). Between seedlings treated with poultry manure + cattle dung and poultry manure, the results did not reveal any appreciable changes ($p > 0.05$).

Table 4: Influence of fertilizers on the mean Leave length of *Eucalyptus torilliana* seedlings (cm)

Treatments	**Leave length**
Poultry manure + Cattle dung	4.79±1.39[a]
Control	4.48±1.21[b]
Cattle dung	4.49±1.37[b]
Poultry manure	4.71±1.59[a]
Mean	4.62±1.40

Mean on the same row with same alphabet are not significantly different at 0.05 levels; ns=not significant.

According to the findings in table 5, seedlings treated with poultry manure + cow dung had the maximum mean leaf width (2.05±1.27a), while control seedlings had the lowest (1.79±0.59b). The outcomes also revealed no differences between seedlings treated with poultry manure, cow dung, and the control ($p > 0.05$).

Table 5: Influence of fertilizers on the mean leave width of *Eucalyptus torilliana* seedlings (cm)

Treatments	**Leave Width**
Poultry manure + Cattle dung	2.05±1.27[a]
Control	1.79±0.59[b]
Cattle dung	1.89±0.76[b]
Poultry manure	1.85±0.77[b]
Mean	1.89±0.89

Mean on the same row with same alphabet are not significantly different at 0.05 levels; ns=not significant.

The impact of fertilizers on the average leaf area of the seedlings is depicted in Table 6. The results showed that there were no differences between seedlings treated with cow dung and poultry manure ($p > 0.05$), but there were differences between seedlings treated with cattle dung plus poultry manure and the control ($p < 0.05$). The seedlings treated with poultry manure + cow dung had the highest mean leave area (10.72±8.03), whereas the control had the lowest mean leave area (8.61±4.52).

Table 6: Influence of fertilizers on the Mean Leave Areaof *Eucalyptus torilliana* seedlings (m^2)

Treatments	**Leave Area**
Poultry manure + Cattle dung	10.72±8.03[a]
Control	8.61±4.52[c]
Cattle dung	9.27±5.89[b]
Poultry manure	9.69±6.08[b]
Mean	9.57±6.29

Mean on the same row with same alphabet are not significantly different at 0.05 levels; ns=not significant.

Weekly growth variables are shown in Table 7. The results revealed a significant change in plant height between weeks 3 and 8 (10.10±1.83). Plant girth varied significantly ($p < 0.05$) from weeks 3, 4, 5, and 8, however there were no significant variations between weeks 6 and 7. No significant differences ($p > 0.05$) were seen between week 4 (9.24±5.75) and week 7 (9.16±5.85) in the results for leaf area. Week 8 had the largest mean leaf area (11.58±8.32), whereas week 3 had the lowest mean leaf area (8.31±5.58). According to the results of the leaf count, the week with the highest mean number of leaves (9.94±5.13) and the week with the lowest mean number of leaves (6.87±2.11) were both weeks.

Table 7: Mean value and Duncan mean separation value for growth variables on the basis weeks.

Weeks after planting	Plant height	Girth	No of leaf	Leaf Length	Leaf Width	Leaf Area
3	6.33 ± 1.53^{f}	1.71 ± 0.39^{e}	6.87 ± 2.11^{d}	4.15 ± 1.43^{d}	1.78 ± 0.86^{b}	8.31 ± 5.58^{c}
4	6.98 ± 1.61^{e}	1.82 ± 0.30^{d}	7.72 ± 3.30^{c}	4.51 ± 1.19^{c}	1.90 ± 0.74^{b}	9.24 ± 5.75^{b}
5	8.22 ± 1.91^{d}	1.90 ± 0.29^{c}	9.94 ± 5.13^{a}	4.49 ± 1.39^{c}	1.84 ± 0.77^{b}	9.13 ± 5.84^{b}
6	9.06 ± 1.82^{c}	2.03 ± 0.27^{b}	8.30 ± 3.35^{b}	4.86 ± 1.39^{b}	1.91 ± 0.64^{b}	10.01 ± 5.54^{b}
7	9.61 ± 1.76^{b}	2.08 ± 0.27^{b}	8.10 ± 3.95^{b}	4.46 ± 1.38^{c}	1.87 ± 0.76^{b}	9.16 ± 5.85^{b}
8	10.10 ± 1.83^{a}	2.25 ± 0.33^{a}	9.85 ± 4.13^{a}	5.25 ± 1.35^{a}	2.08 ± 1.36^{a}	11.58 ± 8.32^{a}
Mean	8.38±2.22	1.97±0.36	8.46±3.93	4.62±1.40	1.89±0.89	9.57±6.29

Mean on the same row with same alphabet are not significantly different at 0.05 levels; ns=not significant.

DISCUSSION

Based on the use of the treatment, E. torelliana seedlings responded strongly ($P < 0.05$). The maximum mean plant height (9.24±2.29) was observed in seedlings treated with cattle dung and poultry manure (5.0 g each). This might be the case since the addition of fertilizers increased the height of the seedlings. The findings were in line with the findings of (Craven *et al*., 2006; Gbadamosi, 2006), which said that a healthy seedling needs to be adequately provided with nutrients in the right quantities for effective growth. Similar result was found by (Focho*et al*., 2011), who reported that, when sufficient fertilizer is applied to seedlings, the yield is higher than when fertilizer is not applied.

According to results on collar girth, plants treated with poultry dung outperformed controls (untreated seedlings). On seedlings treated with poultry manure, the highest mean value (2.05±0.35) was observed, which was higher than that of the control. This is most likely caused by the concentrated nutrients found in poultry manure, which support plant growth. The quantity and quality of nutrients in poultry manure may be higher than in cow dung, which aided in the seedlings' growth. This concurs with the results of research conducted by Ajari*et al*. (2003) and Kuje*et al*. (2019), which revealed that, when compared to other sources of manure, poultry dung promotes seedling growth. The growth performance of some timber seedlings without fertilzer application was shown to be poor by Ong *et al.* in 2003.

There were changes in the number of leaves the seedlings produced that were significant ($p < 0.05$). The seedlings given the combination of poultry manure and cow dung had more leaves on average than the control (9.65±5.62). The findings indicate a substantial difference ($p<0.05$) between the treatments in seedling leaf area. In comparison to seedlings treated with cattle dung, poultry manure, and the control, seedlings treated with poultry manure + cattle dung had the largest (10.72±8.03) mean leave area. This might be the case because the growth of E. torelliana seedlings was accelerated by the application of both cattle dung (5.0g) and poultry manure (5.0g). This was in line with the conclusions of Ogunwale*et al.* (2002) and Kuje*et al.* (2019), who found that the addition of organic fertilizer improved the availability of nutrients to plants, particularly in tropical soils where soil organic matter is typically low.

Results on leaf width revealed that among the treatments, seedlings fed with poultry manure + cattle dung had the greatest mean value (2.05±1.27). This shows that there were differences between the treatments that were significant ($P < 0.05$). Similarly, seedlings fed with both cattle dung and chicken manure had the largest mean leaf length (4.79±1.39). This might be the result of the high nutrient content, particularly nitrogen, in cattle dung and poultry manure, which promoted the growth of the seedlings. This is also consistent with research from Seyedbagheri (1999) and Kuje*et al*. (2019), which found that organic fertilizer promotes the growth of seedlings. Results for the weekly seedling variables demonstrate that there were significant differences in plant height from weeks 3 (6.33±1.53) to 8 (10.10±1.83) but no significant differences in collar girth between weeks 6 (2.03±0.27) and 7 (2.08±0.27) ($P>0.05$). This outcome is consistent with research by Ufere*et al*. (2013), who found related results in their experiment.

CONCLUSION

Based on these results, it can be concluded that the use of organic fertilizers (poultry manure, cattle dung, and a mixture of poultry manure and cattle dung) improved *Eucalyptus toreliana* seedling growth performance in the study area. When compared to untreated seedlings, treated seedlings fared better. The best growth variables were produced by seedlings treated with poultry manure and cow dung, and the treatment with poultry manure was superior to the treatment with cattle dung. Therefore, it is recommended that, *E. toreliana* be produced at nurseries for plantation establishment with the application of poultry manure and cattle dung.

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Characterization of Soils of Ifite Ogwari Campus of Nnamdi Azikiwe University, Anambra State, South Eastern Nigeria

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K E Y W O R D S

Arable land,
Forested land,
Ifite-Ogwari,
Pasture land,
Soil properties

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A B S T R A C T

This study assessed the properties of soils under arable (profile 1), pasture (profile 2) and forested (profile 3) lands at Nnamdi Azikiwe University Ifite Ogwari campus (latitude 06° 60' 13" N and longitude 6° 95' 63" E) to investigate the morphological, physical and chemical properties and determine relationships among them. A total of 12 samples were collected according to horizon differentiation. Soil samples were examined using standard laboratory procedures and data generated were analyzed using coefficient of variation and correlation to determine their relationships. Textural class of arable and pasture lands ranged from loam to sandy loam and forested land from loamy sand to sandy loam. Mottles colour were observed in pasture and forested lands. Variability in pH of arable, pasture and forested lands was 3.85 %, 3.64 % and 0.90 % respectively. The coefficient of variation of organic carbon content was 16.99 %, 39.59 % and 52.50 % in arable, pasture and forested lands respectively. The variability in base saturation was low in arable land (15.24 %) and pasture land (15.12 %) and moderate in forested land (26.88 %). The Organic carbon content correlated with Total nitrogen (TN) and Available phosphorus (AP) in arable and pasture lands and TN, AP and Na in forested land. The soils have low nutrient reserves and use of organic soil fertility management (dungs and composts) was recommended for farmers to increase yields in arable land, improve pasture land and conserve forested land.

INTRODUCTION

Information relating to soil conditions, their current status, changes as a result of land use and management practices is critical for sustainable agriculture, because it is important for proper planning and management of soils. It is imperative to take cognizance of soil properties for planning suitability of crops and reduce massive land deterioration and degradation which hampers the sustainability of soil resources. In recent times forest lands have been affected because of over exploitation as a result of timber production, firewood, expansion of cultivated and grazing lands, resulting in decline of soil fertility and crop production. The indiscriminate use of land can lead to environmental problems such as food insecurity, health and safety hazards and depressed viability of the earth for food production. There should be prior knowledge of soil properties since farmers in Ifite Ogwari use land for various purposes which partly destroy soil structure and reduces fertility and long-term use of soil. Detailed soil survey is a prerequisite for sustainable agricultural development. This study is imperative since population is increasing geometrically with a fixed land mass and there is need to adopt effective land practices by farmers and guidelines for land users for proper land use planning. The objective of the study was to determine the properties of soils of different land use in Ifite Ogwari. The specific objectives of the study were to investigate the morphological, physical and chemical properties of soils of arable land, pasture land and forested land and inter-correlate these soil properties to determine relationships among them.

MATERIALS AND METHODS

The study was conducted at Faculty of Agriculture Nnamdi Azikiwe University Ifite Ogwari Campus (Lat. 06° 60' 14" N and long. 6° 95' 02" E, elevation: 42 MASL) in Ayamelum L.G.A of Anambra state. The geology consists of Lower coal measure, False - bedded sandstone and Imo clay shales (Orajaka, 1975). The hydrology includes floodplains of Omambala River, Ezu River, Du-River and Obina River (Ofomata, 1975). The area has a tropical wet-and-dry climate of Koppen's Aw-type (Inyang, 1975), average annual rainfall of 1700 mm and average mean temperature of 29.0 ^{o}C (NIMET, 2022). The vegetation is that of secondary forests-savannah mosaic, as anthropogenic activities have reduced the density of these forests. (Igbozuruike, 1975). The soils of Ifite Ogwari are generally sandy with accumulation of clay and gravels in most subsurface horizons and moderately to imperfectly drained. The sites include arable land (continuously planted in rotation with rice, maize and pigeon peas), pasture land (mostly of elephant and guinea grasses with few shrubs) and forested land (mainly *Gmelina arborea, Melicia excelsa, Tectona grandis and Ceiba pendandra* trees and woodlands). Profile description was according to horizon boundaries delineation based on the guidelines of FAO (2006). Soil samples were collected from each of the constituent horizon, labeled, air dried, crushed, sieved using 2 mm sieve, re-bagged and sent to the laboratory for analysis. The undisturbed soil samples were used for bulk density and saturated hydraulic conductivity determination.

Laboratory Analyses

Particle size distribution by hydrometer method (Gee and Or, 2002). Bulk Density by core method (Grossman and Reinsch, 2002). Moisture content (Obi, 1990). Saturated hydraulic conductivity by constant head parameter method (Topp and Dane, 2002). The soil pH using pH Meter in 1:2:5 ratio of soil to water (Thomas, 1996). Total nitrogen by Kjeldahl digestion method (Bremmer 1996). Organic carbon by wet digestion method (Nelson and Summers, 1982). Available phosphorus by Bray II method (Olsen and Sommers, 1982). Exchangeable (Ex) base by extracting with 1N NH_4O_{AC} solution, Ex. Ca and Mg by EDTA Complexometric titration. Ex. K and Na by flame photometry (Jackson, 1962). Cation exchange capacity (CEC) by aluminum acetate leaching at pH 7 (Blackemore *et al*., 1987). Total porosity = (F) = 1 – $\underline{e_b}$ / e_s x 100/1, Where: e_b = bulk density (M g/cm^3) and e_s = particle density (2.65 Mg/cm^3). Base saturation (% BS) = TEB/CEC * 100/1.

Statistical Analysis

The GENSTAT statistical package version 12 was used. The coefficient of variation (CV) (%): 0-15 (low variation), 16-35 (moderate variation), 36-100 (high variation) (Wilding *et al*., 1994) and Pearson correlation were used to determine relationships among soil properties.

RESULTS AND DISCUSSION

Results of soil morphological properties are presented in Table 1. Colour varied as strong brown in A (7.5YR 5/6), light brown in AB (7.5YR 6/4), Pale red (7.5YR 7/4) in Bt1 and light red (10YR 6/6) in Bt2 horizons of arable land. Pasture land was reddish yellow in A (7.5YR 6/8), light brown in AB (7.5YR 6/4), yellowish brown in Bt1 (10YR 5/6) and brown in Bt2 (7.5YR 5/4) horizons. Forested land was dark yellowish brown in A (10YR 4/4), brown in AB (7.5YR 5/4), reddish brown in Bg1 (5YR 5/3) and yellowish red in Bg2 (5YR 5/6) horizons. There were reddish yellow (A) and red mottles (Bt1 and Bt2) and red (A, AB and Bg2) and reddish gray (Bg1) mottles in pasture and forested lands respectively. Structure varied as weak, very fine crumb in A horizon of arable, pasture and forested lands, weak, very fine sub angular blocky in AB and Bt1 horizons of arable land and Bt2 horizon of pasture land, weak, fine and sub angular blocky in Bt1 horizon of pasture land, moderate, medium, sub angular blocky (Bt2 horizon of arable land, Bg2 of pasture land), moderate, very fine crumb (AB horizon of pasture land) and moderate, fine and sub angular blocky (AB and Bg1 horizons of forested land). The moist consistencies were friable (A, AB, Bt1 horizons of arable land, A, AB and Bt2 horizons of pasture land and AB horizon of forested land) and firm (Bt2 horizon of arable land, Bt1 horizons of pasture land and A, Bg1 and Bg2 of forested land) in most horizons. Root activities varied as fine and medium and very fine and few in arable and pasture lands respectively and fine and few (A and Bg1) and very fine and few (AB) in forested land. Soils were well drained in most horizons, moderately drained in Bt1 of pasture land and poorly drained in Bg1 and Bg2 of forested land. Horizon boundaries were wavy and clear (A, AB and Bt1 horizons in arable land), smooth and clear (AB horizons of pasture land) and smooth and diffuse (A and Bt1 horizons of pasture land and A, AB and Bg1 of forested land). Soils of forested land were brownish on the surface horizons (0 – 12 cm) and reddish to brownish (12 – 50 cm) at the argillic horizons than arable and pasture lands. This was a result of organic matter influence on soil colour. Mottles colour was due to poor drainage condition, yellowish and reddish colours signified the presence of sesquioxides while pale colour was eluviation or leaching of basic cation and organic matter (Esu, 2010). Variation in structure was due to movement of clay and minerals and bulk density in soils. Crumb structure of soils could be due to continuous addition of organic matter while sub angular blocky nature could be attributed to clay fractions. Presence of plant roots in surface and subsurface horizons was due to the presence of fibrous roots dominance. Boundary forms was a result of lateral movement of soils (Esu, 2010).

Table 1 Macro morphological Properties of Pedons in Ifite Ogwari sites.

Horizon	Depth (cm)	Matrix Colour (moist)	Mottles	Structure	Consistence (moist)	Roots	Drainage	Boundary form
Arable Land (Profile 1)								
A	0 – 17	SB 7.5YR 5/6	-	1, vf, cr	Friable		wd	w, c
AB	17 – 33	LB 7.5YR 6/4	-	1, vf, sbk	Friable	f, m	wd	w, c
Bt1	33 – 54	PR 7.5YR 7/4	-	1, vf, sbk	Friable		wd	w, c
Bt2	54 – 152	LR 10YR 6/6		2, m, sbk	Firm	-	wd	-
Pasture Land (Profile 2)								
A	0 – 20	RY 7.5YR 6/8	RY	1, vf, cr	Friable	-	pd	s, d
AB	20 – 44	LB 7.5YR 6/4	-	2, vf, cr	Friable	vf, fw	wd	s, c
Bt1	44 – 73	YB 10YR 5/6	R	1, f, sbk	Firm	-	md	s, d
Bt2	73 – 158	B 7.5YR 5/4	R	1, vf, sbk	Friable	-	wd	-
Forested Land (Profile 3)								
A	0 – 12	DYB 10YR 4/4	R	1, vf, cr	Firm	f, fw	wd	s, d
AB	12 – 20	B 7.5YR 5/4	R	2, f, sbk	Friable	vf, fw	wd	s, d
Bg1	20 – 50	RB 5YR 5/3	RG	2, f, sbk	Firm	f,fw	pd	s, d
Bg2	50 – 150	YR 5YR 5/6	R	2, m, sbk	Firm	-	pd	-

Key: colour (moist): B = brown, RB = reddish brown, YR = yellowish red, LB = light brown, RY = reddish yellow; RG = reddish gray; PR = pale red, R = red, YB = yellowish brown; Structure: sbk = sub-angular blocky, cr = crumb; 1= weak, 2 = moderate; vf = very fine, m = medium, f = fine, Roots: f, m = fine, medium; vf, fw = very fine, few; f, fw = fine, few; vf, fw = very fine, few; f, m, fine, medium. Drainage: wd = well drained, md = moderately drained, pd = poorly drained; Boundary form: w, c = wavy, clear; s, c = smooth, clear; s, d = smooth diffuse

Physical properties of soils

The physical properties of soils are shown in Table 2. Texture ranged from sandy loam to loam in arable and pasture lands and sandy loam to loamy sand in forested land. Sand fraction had moderate variation in arable (CV = 25.32 %), pasture land (CV = 24.37 %) and forested land (CV = 17.09 %). Clay varied highly in arable land (CV = 53.42 %), pasture land (CV = 50.12 %) and forested land (CV = 39.55 %). Moisture content (MC) increased irregularly across profiles with moderate variation in arable (CV = 18.64 %), pasture land (CV = 34.48 %) and forested land (CV = 25.50 %). Bulk density increased across profiles with low variations in arable land (CV = 6.22 %), pasture land (CV = 7.06 %) and forested land (CV = 2.37 %). Total porosity varied minimally in arable land (CV = 7.29 %), pasture land (CV = 9.14 %) and forested land (CV = 2.81 %). The

KSat values varied from low variation in pasture land (CV = 11.45 %) to moderate in arable (CV = 18.71 %) and forested land (CV = 29.96 %) but decreased irregularly across the profiles. Table2 showed that sand dominated other fractions as reflected in the textural class of the soils which reflects their parent materials.

The accumulation of clay in subsoils was due to the lateral movement or surface erosion. High silt values obtained from pasture and forested lands indicated low degree of weathering (Esu, 2010). Low bulk density values of soils were attributed to organic matter deposition and sorting of material. Total porosity values in soils reflected an inverse relationship with bulk density. The values of KSat was attributed to macro pores, organic matter content and low bulk density of soils.

Table 2 Physical Properties of Pedons in Ifite Ogwari sites

Horizon	Depth (cm)	sand	Silt %	Clay	TC	MC (%)	BD Mg/m^3	TP %	KSat cm/min
Arable Land (Profile 1)									
A	0-17	80.93	14.33	4.74	LS	0.09	1.30	50.94	0.98
AB	17-33	64.72	20.24	15.04	SL	0.13	1.50	43.40	0.72
Bt1	33-54	53.80	26.13	20.04	SL	0.14	1.45	45.28	0.76
Bt2	54-152	45.01	30.00	24.99	L	0.11	1.47	44.53	0.64
	Mean	61.12	22.68	16.20	SL	0.12	1.43	46.04	0.78
	CV (%)	25.32	30.25	53.42		18.64	6.22	7.29	18.71
Pasture Land (Profile 2)									
A	0-20	46.92	30.05	23.03	L	0.15	1.40	47.17	1.06
AB	20-44	39.92	35.04	25.04	L	0.09	1.30	50.94	1.00
Bt1	44-73	54.92	30.04	15.04	SL	0.13	1.50	43.40	0.82
Bt2	73-158	70.60	23.38	6.02	SL	0.21	1.55	41.51	0.89
	Mean	53.09	29.62	17.29	SL	0.15	1.43	45.76	0.94
	CV (%)	24.37	16.15	50.12		34.48	7.06	9.14	11.45
Forested Land (Profile 3)									
A	0-12	66.50	20.44	13.06	SL	0.13	1.40	47.17	1.26
AB	12-20	53.82	28.14	18.04	SL	0.20	1.44	45.66	0.72
Bg1	20-50	60.92	30.04	9.04	SL	0.13	1.42	46.42	0.94
Bg2	50-150	80.20	12.30	7.50	LS	0.18	1.48	44.15	0.67
	Mean	65.36	22.73	11.91	SL	0.16	1.44	45.85	0.90
	CV (%)	17.09	35.62	39.55		22.50	2.37	2.81	29.96

Key: TC=textural class: SL= sandy loam, SCL= sandy clay loam, L = loam, LS = loamy sand, MC = moisture content, BD = bulk density, TP = total porosity, KSat = saturated hydraulic conductivity, LV = low variation, MV = medium variation, HV = high variation

Chemical properties of soils

The chemical properties of soils are shown in Table 3. The pH of soils was strongly to moderately acidic with low variation in arable (CV= 3.85 %), pasture land (CV= 3.64 %) and forested land (CV= 0.90 %). Organic carbon contents of soils had moderate variation in arable (CV = 16.99 %) and high variation in pasture (CV = 39.59 %) and forested land (CV = 52.50 %). Total nitrogen values were moderate in arable (CV = 29.69 %) and high in pasture (CV = 59.07 %) and forested (CV = 55.13 %). Variability of available phosphorus was least in arable land (CV = 1.69 %), moderate in forested land (CV = 27.78 %) and high in pasture land (CV = 41.67 %). Variability of Ca^{2+} (CV = 9.79 %) and Mg^{2+} (CV = 14.01 %) was low while Na^+ (CV = 61.58 %) and K^+ (CV = 98.18 %) was high in arable land. In pasture land variability of Ca^{2+} (CV = 34.57 %) and Na^+ (CV = 41.67 %) was high, Mg^{2+} was low (CV = 9.91 %) while K^+ (CV = 34.29 %) was moderate. The Ca^{2+} (CV = 29.54 %) and Mg^{2+} (CV = 20.23 %) in forested land varied moderately, Na^+ (CV = 61.58 %) and K^+ (CV = 98.18 %) varied highly. The CEC varied minimally in arable land (CV = 7.25 %), pasture land (CV = 11.08 %) and forested (CV = 11.25 %). The base saturation was least in arable land (CV = 15.24 %) and pasture land (CV = 15.12 %) and moderate (CV = 26.88 %) in forested land. From the results soil reactions (pH) were generally acidic and could be due to leaching of basic cations. Average organic carbon content was below critical level (2 - 3 g/kg) for tropical soils (Landon, 1991). Arable and forested land average TN values were higher than pasture land and could be linked to high organic carbon content of soils. Available phosphorus values were generally low (< 3 mg/kg) (FDALR, 1990) and could be due to sorption reaction of soils. Exchangeable Ca^{2+} dominated in soils but was < 4 cmol/kg critical limit (FDALR, 1990). Exchangeable Mg^{2+} and Na^+ were rated low (0.3 – 1.0 cmol/kg) and very low (< 0.10 cmol/kg) respectively in all pedons studied and fell below critical limits for fertile soils while forested land was rated low (0.2 – 0.3 cmol/kg) (FDALR, 1990). The CEC values were low (6 - 12 cmol/kg) (FDALR, 1990) due to leaching, low organic carbon and clay contents which hold nutrients in these soils. Base saturation of soils was rated low (20 – 40 %) for pasture and forested land and moderate (40 – 60 %) for arable land (FDALR. 1990).

Table 3 Chemical Properties of soils of Ifite Ogwari study sites

Horizon	Depth (cm)	pH	OC g/kg	TN	AP Mg/kg	Ca Cmol/kg	Mg	Na	K	H	Al	TEB	CEC	BS %
Arable Land (Profile 1)														
A	0-17	5.50	3.50	0.34	0.018	2.85	1.65	0.184	0.02	0.18	0.09	4.71	9.98	47.19
AB	17-33	5.10	4.40	0.39	0.022	2.70	1.40	0.226	0.23	0.38	0.19	4.55	9.92	45.87
Bt1	33-54	5.10	3.30	0.23	0.017	2.62	1.20	0.178	0.18	0.22	0.43	4.18	10.66	39.21
Bt2	54-152	5.10	3.00	0.21	0.015	2.25	1.60	0.015	0.02	0.43	0.24	3.88	11.56	33.56
	CV (%)	3.85	16.99	29.69	1.69	9.79	14.01	61.58	98.18	40.32	60.25	8.61	7.25	15.24
Pasture Land (Profile 2)														
A	0-20	5.00	3.80	0.36	0.019	1.62	1.88	0.019	0.21	0.282	0.14	3.73	13.15	28.37
AB	20-44	5.20	2.30	0.16	0.012	2.50	1.70	0.012	0.13	0.386	0.20	4.34	11.92	36.41
Bt1	44-73	5.40	2.00	0.14	0.010	1.12	1.50	0.010	0.11	0.190	0.10	2.74	10.03	27.32
Bt2	73-158	5.40	1.60	0.11	0.008	2.42	1.58	0.008	0.11	0.224	0.11	4.12	11.45	35.98
	CV (%)	3.64	39.59	59.07	41.67	34.57	9.91	41.67	34.29	31.73	32.85	18.97	11.08	15.12
Forested Land (Profile 3)														
A	0-12	5.60	3.80	0.33	0.02	2.50	1.50	0.019	0.21	0.250	0.40	4.22	10.60	39.81
AB	12-20	4.90	4.40	0.37	0.02	2.50	1.00	0.022	0.23	0.267	0.43	3.75	9.12	41.12
Bt1	20-50	4.90	3.00	0.30	0.02	1.20	1.12	0.015	0.18	0.267	0.40	2.51	11.97	20.97
Bt2	50-150	4.90	0.80	0.05	0.01	2.10	1.50	0.004	0.04	0.180	0.37	3.64	10.20	35.69
	CV (%)	0.90	52.50	55.13	27.78	29.54	20.23	53.33	52.15	17.01	6.00	20.54	11.25	26.88

Key: pH H_20= pH in water, TN=total nitrogen, AP=available phosphorus, TEB=total exchangeable bases, CEC=cation exchange capacity

Correlation coefficients of soils

Pearson correlation matrix of soils in arable had Clay correlated and positively with moisture content (MC) and negatively with total nitrogen (TN). The organic carbon (OC) content was positive and highly significant with TN (**0.9041) and available phosphorus (AP) (**0.9956). In pasture land Clay was highly significant with MC (**- 0.8436) and total porosity (TP) (**0.9003) and significant with TN (*0.5961). The OC content was highly significant with positive and negative correlations with TN (**0.9926) and AP (*-0.9956) respectively. In forested land Clay correlated positively and highly significantly with TP, OC and TN and significantly with AP. Total nitrogen (TN) was highly significant and correlated positively with K (**0.9971).

CONCLUSION AND RECOMMENDATIONS

Results of soil properties of study sites showed that different land use varied with soil properties. The order followed a decreasing style as in OC and AP: Arable land > forested land > pasture land, Ex. K: Pasture land > forested land, CEC: Pasture land > forested land > arable land and Base Sat: Arable land > forested land > pasture land. Since these soils have low nutrient reserves, it was therefore recommended that the use of organic soil fertility management (dungs and composts) be adopted by farmers to increase yields in arable land, improve pasture land while forested land is conserved.

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Influence of the Levels of Soil Contamination on the Early Growth Performance of *Adansonia digitata* Linn. Seedlings

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KEYWORDS

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Soil contamination

ABSTRACT

The indiscriminate discharge of spent engine oil is a major source of soil pollution and the influence of the levels of soil contamination on the early growth and performance of Adansonia digitata was investigated at the forest nursery for the period of twelve weeks. Contaminated and top soil were collected from mechanic garage and Forest Nursery respectively. An headpan was used to measured the contaminated and top soil at gazetteed ratio such as: T1(1:0) Contaminated soil only, T2(1:1) Contaminated soil and top soil, T3 (1:2) Contaminated soil and top soil and T4 (0:1) top soil only. The experimental set up was laid in completely randomization design (CRD) with four treatments and five replicates. Morphological attributes such as shoot height, collar diameter and number of leaves were measured fortnightly for the period of twelve (12) weeks. Inferencial statistics such as Analysis of Variance was employed. The findings revealed that T2 (1:1) contaminated soil and top soil had the best growth vigour in terms of shoot height (4.36 cm) and stem diameter (1.34cm) and its leave mumber followed the best (94.6) and there is significant differences at (p>0.05) level of significance. It can be inferred from the study that Adansonia digitata can be planted at mechanic garages and contaminated soil for cleaning the soil pollution and environment. Further research can be intensified for improvement of the species in terms of economics and ecological benefits it possess.

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INTRODUCTION

Adansonia digitata is one of the most important Non-Timber Forest Products (NTFP) providing species with significant ecological and socio-economic significance. It is among the nine global species of baobab in the genus Adansonia from the family Malvaceae and subfamily Bombacaceae (Jen *et al.,* 2016; Salami *et al*., 2018a). Most scientists know the vernacular name of the species as 'baobab' which globally derived it name from the Arabic name "buhibab" meaning fruit with many seeds (Diop *et al.*, 2006; Clayton 2012). The genus name Adansonia is used in nobility of the botanist Michel Adanson (1727–1806), whilst the species name digitata (hand-like) was selected in reference to the shape of the leaves (Döring, 2022). Apart from *Adansonia digitata* which is native to Africa; there is the Australian baobab, *Adansonia gibbosa*, *A. Cunnand* and six other baobab species native to Madagascar namely *Adansonia grandidieri* Baill. *A. madagascariensis* Baill. *A. rubrostipa* Jum and H. Perrier, A. *perrieri capuron, A. suarezensis* H. Perrier. This is the most widespread baobab in Madagascar (Salami *et al.,* 2019). The ninth species that was recently discovered in Africa through morphology, ploidy and molecular phylo genetics research is *Adansonia kilima* Pettigrew *et al.,* (2012). *Adansonia kilima* was found to be superficially similar to *A. digitata* though it could be differentiated on the basis of floral morphology, pollen characters and chromosome number Douie *et al*., (2015).

Adansonia digitata (baobab) is one of the widespread multi-purpose tree species in Southern Africa. It is popularly known as "Africa's upside down tree" due to its structure. Throughout its range, the baobab makes important contribution to people's livelihoods for food, fibre and medicine (Emmy *et al.,* 2010). Baobab trees form a key source of income, especially in the dry season and during times of drought (Sidibe and Williams, 2002). According to Sidibe and Williams (2002), baobabs have an outstanding ability to withstand severe drought and fire, which are two major hazards to plant life in dry areas of Africa. Although baobabs are mostly regarded as fruit-bearing trees, they are multipurpose, widely-used species with medicinal properties, numerous food uses of various plant parts, and bark fibers that are use for a wide range of purposes (Salami *et al.,* 2021; Dhillion and Gustad, 2004; Wickens and Lowe, 2008). Up to 300 uses of the baobab were documented in Benin, Mali, Zimbabwe, Cameroon, the Central African Republic, Kenya, Malawi, South Africa and Senegal across eleven ethnic groups and four agro-ecological zones (Salami *et al.,* 2021; Buchmann *et al.,* 2010). The fruits and leaves are harvested and stored for consumption throughout the year (Buchmann *et al.,* 2010). Fruit harvesting of baobabs normally starts from April to May in Southern Africa and from October to November in West Africa (Sidibe and Williams, 2002). However, there are some baobab trees that can go for several years without fruiting or that do not produce fruit at all and such baobabs have been categorized as 'poor producers' (Venter and Witkowski, 2011) or in some areas as 'male' baobabs (Assogbadjo *et al.,* 2009). Farms and nurseries use various seedling and potting media in the production of field transplants, container plants, and greenhouse crops. Such media may contain a wide range of natural and synthetic materials. Soil is very important to man existence for various reasons especially plant growth which man depend entirely for survival. Soil contamination or soil pollution as part of land degradation is caused by the presence of xeno-biotics (human-made) chemicals or other alteration in the natural soil environment Akintola *et al.*, (2019). It is typically caused by industrial activity, agricultural chemicals or improper disposal of waste. Contamination of soil by crude oil and its products has been a widespread environmental problem. Spent engine oil has been known to contain heavy metals which is not only harmful to the soil and human health but to plants, their germination and survival. Oil spills from flow stations, boat fuel spill, oil leakages and deliberate dumping of motor oil or other oil products into the environment lead to slip contamination at large (Fasawe *et al.,* 2021). Disposal of spent lubricant into gutters, water drains, open plots and farms is a common practice especially by motor mechanics in Nigeria which in one way or the other effect soil quality. This Indiscriminate discharge of spent lubricating oil (SLO) is a major source of diffuse or non-point source of oil pollution to the environment. This creates a serious monitoring and control challenge as mechanic workshops and mechanic villages spring up every day and everywhere without plan and policy for management of waste and protection of the environment. The presence of spent lubricant oil in soil increases the bulk density, decreases water holding capacity and aeration propensity (Kayode *et al.,* 2009). Balanites offers ways to help address pressingenvironmental problems such as desertification, andprevention of soil erosion (Mohammed *et al.,* 2023; Gumbo, 2010). This study tried to observe the bioremediation capacity of the boabab in combating the contaminated soil into green productive means by observing the early growth performance of the species at different level of contamination.

MATERIALS AND METHODS

Description of the area of study

This study was conducted in Forest Nursery of the Department of Forestry and Wildlife Management, Federal University Dutse, Jigawa State. University falls between latitudes 11^0 39' to $11^0$69'N and longitude 9^o15' to $9^{0'}$ 36E. The amount of rainfall receives annual is usually around 743 mm. The average annual temperature is 35^0C. The topography is characterized by high land area which is almost 750meters. Soil tends to be fertile ranging from sandy-loam (Salami and Lawal, 2018b).

Materials

The material used for the study comprised of contaminated soil from mechanic garage, uncontaminated soil (top soil), river sand, Seeds of Adansonia, Polythene bags, Nursery tools, meter rule.

Soil collection

Contaminated soil was collected from mechanic garage and top soil was also collected from the school farm while river sand sourced from the Forestry and Wildlife nursery.

Collection of seed

Ripe seeds of the species were collected from the mature mother tree from the forest nursery in the Department of Forestry and Wildlife Management Federal University Dutse, Jigawa State

Experimental design and procedure

The experiment was design to assess the effect of contaminated soil on the early growth performance of *Adansonia digitata* (Baobab) where contaminated soil collected from mechanic garage was mixed with clean soil (top soil) of the Forest Nursery in a ratio of T1 (1:0) contaminated soil only, T2 (1:1) contaminated soil and top soil, T3 (1:2) contaminated soil and top soil, and T4 (0:1) top soil only respectively. In each of the treatments, five (5) pots were filled and stalked in the following design. The seeds of Baobab were placed in water to ascertain the viability of the seeds those that float on the water are regarded as unviable seeds while those that sunk to the bottom are considered as the viable seeds. The viable seeds were soaked in boil distilled water at 100°C for 10 minutes in a 100 ml flask before sowing in the potting mixture (Adeniji *et al.,* 2017; Salami *et al.,* 2019). The experimental set up was watered once daily and germination was monitored till the count germination count was observed and recorded. The treatments were arranged in a Completely Randomized Design with five replications. After two weeks of transplanting from the seed bed to the pots. The early growth study was monitored and recorded every two weeks for the period of twelve weeks. Morphological attributes such as number of leaves which were counted, shoot heights were measured using ruler and collar diameter were measured with the aid of vernier caliper.

Table 1: Showing the arrangements of the treatments in the field

Replicate	T1	T2	T3	T4
R1	T1R1	T2R2	T3R1	T4R1
R2	T1R2	T2R2	T3R2	T4R2
R3	T1R3	T2R3	T3R3	T4R3
R4	T1R4	T2R4	T3R4	T4R4
R5	T1R5	T2R5	T3R5	T4R5

Data analysis

Data collected on the impact of different contamination levels on the growth performance of Baobab seedlings at nursery stage were subjected to Analysis of Variance (ANOVA) using SPSS version 16.00

Results and discussion

The table below is designed to give a clear view of the research work conducted and the findings obtained from first day to last data taken

Table 2: showing the mean of morphological features of the species

Treatment	Shoot height (cm)	Collar diameter (mm)	Leave number
T1	3.52	1.19	63.80
T2	4.36	1.34	94.60
T3	3.36	1.09	99.20
T4	1.76	0.96	40.00

Source: Field survey, (2022)

Results obtained from the field showed in Table 2. T2 had the highest mean shoot height performance (4.36 cm), followed by T1 with the mean value of (3.52 cm) followed by T3 with (3.36 cm). The least performance is T4 with the (1.76 cm) mean respectively. There are significant differences among the treatments at ($p>0.05$) level of significance. Table 2 showed that T2 had the highest diameter with (1.346mm) followed by T1 with (1.19) and T3 with (1.09) respectively. The least performance is T4 with the 0.962mm. There are significant differences among the treatments at ($p>0.05$) level of significance. Table 2 showed that T3, T2 and T1 had the highest leaves number with the mean of 99.2, 94.6 and 63.8 respectively followed by T1 with (40). There are significant differences among the treatments at ($p>0.05$) level of significance.

Table 3: showing the Analysis of variance (ANOVA) for the shoot height of *A. digitata* seedlings

Source of variation	Sum of Squares	Df	Mean Square	F cal	Sig.
Between Groups	17.687	3	5.896	20.017	0.000
Within Groups	4.713	16	0.295		
Total	22.400	19			

Note : the treatment diffrencess is highly significant at ($p>0.05$) level of significance

Table 4: showing the Analysis of variance (ANOVA) for the coller diameter of *A. digitata* seedlings

Source of variation	Sum of Squares	Df	Mean Square	F cal	Sig.
Between Groups	.392	3	.131	5.430	0.009
Within Groups	.385	16	.024		
Total	.777	19			

Note: the treatment differences is significant at ($p>0.05$) level of significance.

Table 5: showing the Analysis of variance (ANOVA) for the leave number of *A. digitata* seedlings

Source of variation	Sum of Squares	Df	Mean Square	F cal	Sig.
Between Groups	11594.000	3	3864.667	60.813	0.000
Within Groups	1016.800	16	63.550		
Total	12610.800	19			

Note : the treatment is significant at ($p>0.05$) level of significant

DISCUSION

Application of sewage sludge to agricultural land is widely practiced and presumed to be beneficial for plants' growth. However, sewage sludge is often contaminated by heavy metals, organic pollutants, and pathogens (Liphadzi and Kirkham, 2006). This study assessed the ability of *Adansonia digitata* seedlings to accumulate and adapt to the environment. The finding inferred from Table 2 showed that T2 had the highest mean shoot height (4.362cm), followed by T1 with 3.524cm respectively. However, T4 (control) had the least performance with 1.762cm. T2 had the highest mean diameter with 1.35mm followed by T1 with (1.194mm) followed by T3 with (1.09) mean as shown in Table 2 . T3, T2 and T1 had the highest leave production with the mean of 99.2, 94.6 and 63.8 respectively. T4 (control) still had the least leaf counts. There are significant differences among the treatments at 5% probability level for all the morphological characteristics of the species. This study is in agreement with the report of Fasawe (2021) that *Adansonia digitata* can germinate, grow and survive in spent engine oil polluted soils or over used engine oil Akintola *et al.*, (2019) also agreed that there is significant reduction observed in concentrations of heavy metals in the soils before and after planting indicated their enrichment in the plant tissues. It was also reported by Olajuyigbe *et al*., (2019) that Terminalia ivorensis and Hildergardia barteri can grown and survive in spent engine oil. However, Olajuyigbe and Akande (2023) supported the study which showed that control treatment had the highest seedling height and collar diameter, indicating that height increase was inversely related to the increase in spent engine oil concentration. In addition, spent engine oil contamination had a negative influence on leaf production. Furthermore, Jibo *et al*., concurred that the mixture poultry manure, rivers and and topsoil can improve the soil quality for the production of the *Eucalyptus camaldulensis* in the nursery for plantation purposes.

CONCLUSION AND RECOMMENDATIONS

This study showed that *Adansonia digitata* can grow and survive in spent engine oil or over used engine oil. Finding revealed that the species respond well for all morphological features and perform better in both contaminated and top soil. This study therefore, recommended that *Adansonia digitata* can be planted at mechanic garages or avenue planting for cleaning the soil pollution and environment. Further research can be intensified for improvement of the species in terms of economics and ecological benefits it possess.

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SUB-THEME 4

FOOD SCIENCE AND SECURITY ISSUES IN THE FACE OF CHANGING CLIMATE

Sensory Evaluation and Physicochemical Qualities of Maize-Based Flaked Snacks Complemented with *Mucuna Pruriens* Seed Flour

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KEYWORDS

Maize,
Mucuna,
Snacks,
Flour,
Complement

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ABSTRACT

The objective of this study was to produce Maize-Mucuna pruriens seed flaked snacks and evaluate their consumer acceptability and physicochemical properties. Maize was cleaned, tempered, decorticated, milled and sieved to obtain maize flour. Mucuna pruriens seed was soaked (twice for 6 h respectively with change of water), dehulled, boiled (1 h), dried (70ºC) and milled into flour. The five Maize-Mucuna seed flour ratios were formulated as follows: 95:5 (EFA), 90:10 (EMU), 85:15 (PRO), 80:20 (UZY) and 100:0 (ABC – control). The snacks proximate composition, functional and sensory qualities were evaluated. With the addition of Mucuna pruriens seed flour the moisture content of the samples had no significant difference (p > 0.05) while significant increase (p < 0.05) existed in the ash and protein contents. Sample with 90:10 Maize:Mucuna flour (EMU) had the lowest value of 7.20% while sample with 80:20 Maize:Mucuna seed flour (UZY) had the highest protein value of 11.59%. Swelling power increased significantly (p < 0.05) with inclusion of Mucuna pruriens seed while water absorption capacity decreased significantly (p < 0.05). Sample with 80:20 Maize:Mucuna flour (UZY) had the lowest water absorption capacity (183 g/ml). The control sample ABC (100:0 Maize:Mucuna) had the highest overall acceptability score (8.33) and significantly differed from the other samples. Inclusion of Mucuna pruriens seed significantly reduced the overall acceptability of the snacks. This research showed that maize-based snacks could be complemented with up to 20% Mucuna pruriens seed flour which could help decrease protein-energy malnutrition.

INTRODUCTION

Street foods such as snacks are one of the major energy contributors in the world (Félix-Medina *et al*., 2021). Snacks are foods or beverages that are consumed in between main regular meals without being substituted for the regular meals (Almoraie *et al.*, 2021). They are largely characterized with low nutritional value compared to main meals, irrespective of the form or amount eaten (Almoraie *et al*., 2021). The demand for snacks has increased over the years as a result of change in feeding behaviour, elevated durations at work, increasing population of single persons in households and disparity in the timing for feeding (Sahua *et al*., 2022). Snacks play an important role in between meals in reducing hunger in both growing and aged persons (Netshishivhe *et al*., 2019). A number of raw materials have been used in snacks production including maize (Sahua *et al*., 2022). Notably, the most consumed and popular dry snacks are made from flours gotten from cereal grains; most especially from maize (Netshishivhe *et al*., 2019).

Amongst the many snacks that exist, maize is the major raw material for dry snacks production as it is contained in many of the popularly consumed dry snacks around the globe (Netshishivhe *et al*., 2019). Maize (*Zea mays* L.) is a cereal crop with edible grains and a member of the grass family *Poaceae.* It is considered as a staple food in many countries in Latin America, Africa, and some parts of Asia (Ramos *et al*., 2022). Maize (*Zea mays* L.) is widely cultivated throughout the world (Ten Berge *et al*., 2019; Yan *et al*., 2022) and it is a relatively affordable crop (Ramos *et al*., 2022). Nonetheless, maize is nutritionally deficient as regards its protein quality which is limiting in lysine and tryptophan (Félix-Medina *et al*., 2021) as well as its minerals' composition. These nutritional considerations necessitate complementation processes to ensure that these limiting nutrients are captured during the formulation of maize-based snacks. Sequel to these identified nutritional deficits in cereals like maize, legumes have been unequivocally identified as being ideal for complementation with legumes in cereal-based snacks (Sahua *et al*., 2022).

Velvet beans (*Mucuna pruriens*), is a specie of *Mucuna* and belongs to *Leguminosae family* and has been identified as an underutilized tropical legume in Africa and parts of America and Asia (Adebayo-Oyetoro *et al*., 2021). It grows in arid and infertile terrains, has high nutritional value, is relatively cheap price and widely cultivated in Nigeria (Fitriyah *et al*., 2021). It is nutritionally comparable to other legumes like soybean because of their similar contents of protein, fibre and carbohydrate (Fitriyah *et al*., 2021). *Mucuna pruriens* seed is a good source of crude protein (24 - 31.44 %), crude carbohydrate (42.79 - 64.88 %), crude fibre (5.3 - 11.5 %), ash (2.9 - 5.5 %) (Natarajan *et al*., 2012). *M. pruriens* seed is also rich in minerals such as iron (1.3-15 mg/100g), calcium (104-900 mg/100g) and zinc (1-15 mg/100g) (Pathania *et al*., 2020) as well as lysine, an essential amino acid that is deficient in cereals (Fitriyah *et al*., 2021).

The incorporation of *Mucuna pruriens* seed flour to maize-based snacks has the tendency of nutritionally complementing and improving the quality of the maize-based snacks by enhancing some nutrients that are limiting in maize, create variety of maize-based snacks and increase the utilization of *Mucuna pruriens* seed which is under-utilized. It is on this basis that this research set out to produce and evaluate the sensory and physicochemical qualities of maize-based flaked snacks complemented with *Mucuna pruriens* seed flour.

MATERIALS AND METHODS

Source of Materials

The maize (*Zea mays*) and velvet bean (*Mucuna pruriens*) were bought from Eke-Awka market in Awka, Anambra state. The chemicals used were of analytical grade. At the time of purchase, it was ensured that the materials do not show any sign of deterioration or physical damage.

Experimental Design

A mixture design was used. The five Maize: Mucuna seed flour ratios formulated were as follows: 100:0 (ABC), 95:5 (EFA), 90:10 (EMU), 85:15 (PRO) and 80:20 (UZY).

Maize flour preparation

The grit non-soaking (GNS) method was used to produce maize flour (Olajide and Nsakpuma, 2019). Stones, broken kernels and other foreign objects were manually removed from maize grains. The cleaned grains were tempered by sprinkling with 5% water (v/w) and mixed thoroughly. Following that, the grains were decorticated on a locally built corn decorticating machine to obtain maize grits. The grits that were obtained were utilized wisely. The grits were processed using a disc attrition mill (9FC-36, China) and sieved using a 40-mesh sieve for the grit non-soaking procedure (0.450 mm). The flour was sealed in airtight polyethylene bags (Ziploc, China) and kept at 27±2°C until it was needed.

Mucuna pruriens (Velvet beans) seed flour preparation

The seeds were first soaked for 6 h at room temperature (25°C), changed and steeped for another 6 h in tap water with a seed to water ratio of 1 to 10 (w/v). After soaking, the seeds were dehulled by hand, boiled for one hour and dried at 70°C for 24 h. The dehulled seeds were ground into flour with a hammer mill, sieved through a 200 µm mesh sieve and stored in polyethylene bags for analysis.

Maize based flaked snacks production

The procedure described by Al-Okbi *et al*. (2012) was adopted for the snacks production. In a large bowl, these ingredients were mixed together: 192 g of Maize-*Mucuna pruriens* seed composite flour, sugar (15 g), salt (2.1 g) and vanilla extract (4.2 g). A small amount of water (178 ml) was added and stirred until the batter is smooth. A lining was made on a baking tray with foil and it was lightly greased with vegetable oil (Power oil, Raffles Oil LFTZ Enterprise, Lagos, Nigeria). The batter was poured into a tray, spread out evenly and cut into thin layers of about 0.3 to 0.4 inches. It was flaked in an oven at (250°C) for 4 minutes. The temperature was afterwards lowered to 120°C and allowed for 5 minutes to attain a golden brown colour and crispy. Snacks was cooled and stored in airtight jars for analysis.

Determination of Proximate Composition

Samples were evaluated for % moisture, % ash, % fat, % crude fibre and % crude protein as described by AOAC (2000).

Functional Properties Determination

Bulk density, water and oil absorption capacity, solubility and swelling index were determined as described by Onwuka (2018).

Sensory evaluation

The method described by Iwe *et al*. (2014) was adopted for the sensory evaluation. A sensory panel of 20 semi-trained panelists evaluated the quality features of the "flaked snacks". They rated the samples on a 9-point Hedonic scale for taste, colour, texture, aroma, and overall acceptability, with 9 representing strongly like and 1 representing extremely dislike.

Statistical Analysis

The Statistical Package for Social Science (SPSS) version 23.0 software was used to analyze the data. Duncans Multiple Range Test was used to detect significant differences ($p < 0.05$) among the sample means using Analysis of Variance (ANOVA) and Least Significant Difference (LSD) for separation of significant means.

RESULTS AND DISCUSSION

Proximate Composition of maize-based snacks complemented with *Mucuna pruriens* seed flour.

The proximate composition of the samples revealed significant differences ($p < 0.05$) in the ash, crude fibre, protein, carbohydrate, moisture and fat levels as shown in Table 1.

Table 1: Proximate composition of maize-based snacks complemented with *Mucuna pruriens* seed flour

Sample code	Maize: Mucuna	Moisture content (%)	Crude protein (%)	Ash (%)	Crude fibre (%)	Crude fat (%)	Carbohydrate (%)
ABC	100:0	$7.00^{a}\pm2.65$	$9.40^{c}\pm0.26$	$1.67^{a}\pm0.03$	$10.30^{a}\pm0.26$	$9.40^{c}\pm0.26$	$69.63^{e}\pm0.03$
EFA	95:5	$8.20^{a}\pm0.26$	$8.30^{d}\pm0.10$	$1.50^{c}\pm0.03$	$9.55^{b}\pm0.03$	$8.30^{d}\pm0.26$	$70.48^{c}\pm0.03$
EMU	90:10	$7.50^{a}\pm0.26$	$7.20^{e}\pm0.02$	$1.45^{d}\pm0.03$	$7.40^{c}\pm0.26$	$7.20^{e}\pm0.26$	$74.61^{a}\pm0.03$
PRO	85:15	$8.30^{a}\pm0.26$	$10.40^{b}\pm0.10$	$1.40^{e}\pm0.03$	$6.30^{d}\pm0.26$	$10.40^{b}\pm0.26$	$71.84^{b}\pm0.03$
UZY	80:20	$7.60^{a}\pm0.26$	$11.50^{a}\pm0.10$	$1.55^{b}\pm0.03$	$6.40^{d}\pm0.26$	$11.50^{a}\pm0.26$	$71.40^{d}\pm0.03$

Values are means ± standard deviation of triplicate determinations. Values in the same column with different letters differed significantly ($p < 0.05$).

The moisture content (%) of the samples ranged from 7- 8.3, with 100 % maize flour (ABC) having the lowest moisture content of 7.0 and sample PRO (85:15 Maize:Mucuna flour) having the highest moisture content of 8.3%. The moisture content of the flour blends did not differ significantly ($p > 0.05$). The relatively low moisture content would have resulted from the flaking process during which the samples would have lost moisture. The relatively low moisture content of the samples indicated better storage stability of the flakes. The American Association of Cereal Chemists (2001) approved techniques for measuring various flour qualities state that the higher the moisture content, the less dry particles in the flour. The moisture level of flour is normally limited to 14% or below in flour specifications (Iwe and Onadipe, 2001). At room temperature, grains with moisture content greater than 14% are unstable and organisms present will begin to thrive, causing off odours and flavours.

The percentage crude protein in the flours varied between 7.2 and 11.5. There were significant differences ($p < 0.05$) in the crude protein contents of the samples. Increased quantities of *Mucuna pruriens* seed flour inclusion increased the protein content of the flours (Table 1). The higher proportion of protein in *Mucuna pruriens* seed flour would have resulted in an increase in crude protein content. This increase in crude protein with increased *Mucuna pruriens* flour inclusion was not unexpected, and it served as the foundation for formulating the blends so that the final product would have not only higher protein but also better protein quality.

The fat content of the flakes was generally low (Table 1), ranging from 6.3% (PRO) to 10.93% (ABC). This could be related to the low-fat content of cereals and legumes. Amongst the samples, there were significant differences ($p < 0.05$). Low-fat levels are advantageous because they offer a longer shelf life for the items since unsaturated fatty acids in fats and fat-containing foods are prone to oxidative rancidity (Félix-Medina *et al*., 2021). Sample PRO (85:15 Maize: Mucuna flour) had the lowest fat content (6.3%), whereas the control sample ABC (100:0 Maize:Mucuna flour) had the greatest fat content (10.3%).

The ash content of the flours varied between 1.4 and 1.67%, with sample PRO (85:15 Maize: Mucuna flour) having the lowest value (1.40%) and sample ABC having the highest value (1.67%). There were significant differences ($p < 0.05$) between the samples. Except for UZY (80:20 Maize:Mucuna flour), the ash content decreased significantly ($p < 0.05$) as the amount of *Mucuna pruriens* seed flour inclusion was increased. The amount of ash in a food sample indicates the mineral elements components that are present. It showed the composition of inorganic elements after incineration had destroyed organic materials (fats, proteins, and carbohydrates) and moisture. It's essentially a food sample's aggregate of all minerals it contains. Minerals are a collection of essential nutrients that are found in molecules like haemoglobin, adenosine triphosphate (ATP), and deoxyribonucleic acid (DNA) and serve a variety of key metabolic roles ( ).

The crude fibre level of the flour blends ranged from 1.55 to 2.00%. There were significant differences ($p < 0.05$) between the samples. UZY flour sample (80:20 Maize:Mucuna) had the lowest value (1.55%) while sample ABC (100:0 Maize:Mucuna flour) had the highest value (2.00%). The crude fibre content of sample ABC (100:0 Maize: Mucuna) flour was highest at 2.00% and reduced when the amount of *Mucuna pruriens* seed flour was increased. The crude fibre content of the blends decreased significantly ($p < 0.05$) as the percentage of legume flour substitution rose. This could be due to legumes' relative lower crude fibre compared to Maize which had a decreasing impact on maize. Crude fibre reduces the risk of colon cancer by slowing the flow of glucose into the bloodstream and lowering inter-colonic pressure (Ten Berge *et al*., 2019).

The carbohydrate composition of the flake samples ranged from 69.63- 74.61%, with ABC (100:00 Maize: Mucuna flour) having the lowest carbohydrate content of 69.63% and EMU (90:10 Maize:Mucuna flour) having the greatest carbohydrate content (74.61%). The carbohydrate contents of the flours and their blends were significantly different ($p < 0.05$). The carbohydrate content of the flaked snacks significantly increased with the inclusion of *Mucuna pruriens seed*. These flake samples have high carbohydrate content, indicating that the products will be good sources of energy.

Functional Properties of maize-based snacks complemented with *Mucuna pruriens* flour

Table 2 shows the functional properties of flaked maize-based snacks complemented with *Mucuna pruriens* seed flour. The water absorption capacities of Maize:Mucuna flours - ABC (100:0), EFA (95:5), EMU (90:10), PRO (85:15) and UZY (80:20) were 200, 210, 205, 197 and 183 g/ml

Table 2: Functional properties of maize-based snacks complemented with *Mucuna pruriens* seed flour

Sample code	Maize: Mucuna	WAC (g/ml)	OAC (g/ml)	SP (mg/g)	Solubility (mg/g)	Bulk density (mg/g)	pH
ABC	100:0	$200^{c}\pm1.00$	$160^{b}\pm1.00$	$10^{d}\pm1.00$	$23^{a}\pm1.00$	$0.50^{d}\pm0.10$	$8.0^{a}\pm2.65$
EFA	95:5	$210^{a}\pm1.00$	$156^{c}\pm1.00$	$11^{cd}\pm1.00$	$22^{ab}\pm1.00$	$0.65^{c}\pm0.10$	$8.6^{a}\pm0.26$
EMU	90:10	$205^{b}\pm1.00$	$140^{e}\pm1.00$	$12^{c}\pm1.00$	$21^{ab}\pm2.65$	$0.74^{bc}\pm0.03$	$8.7^{a}\pm2.08$
PRO	85:15	$197^{d}\pm1.00$	$149^{d}\pm1.00$	$14^{b}\pm1.00$	$18^{bc}\pm2.65$	$0.83^{ab}\pm0.03$	$9.4^{a}\pm0.26$
UZY	80:20	$183^{e}\pm1.00$	$164^{a}\pm1.00$	$16^{a}\pm1.00$	$15^{c}\pm2.65$	$0.92^{a}\pm0.01$	$9.7^{a}\pm0.26$

Values are means ± standard deviation of triplicate results. Values in the same column with different letters are significantly different ($p < 0.05$). WAC; water absorption capacity, OAC; oil absorption capacity, SP; swelling power, BD; bulk density.

respectively (Table 2). With the addition of *Mucuna pruriens* seed flour, the samples' water absorption capacity increased. Lorenz and Collins (2004) stated that water absorption capacity is a significant functional feature in food compositions, particularly those involving dough handling. Different protein concentrations, their degree of interaction with water, and their structural features may account for the observed variance in water absorption capabilities between ABC (100:0 – Maize:Mucuna) and other flour blends. This effect could be due to the starch granules' loose association of amylose and amylopectin, as well as reduced associative factors that keep the granular structure together (Lorenz and Collins, 2004)). The ability to absorb water is vital for product bulking and consistency, as well as baking. This shows the capacity the flakes have in absorbing water when water will be added for its consumption. Oil absorption capacity is an important functional property that improves mouth feel while retaining food flavour (Lorenz and Collins, 2004). The oil absorption capacity of the flour samples differed significantly ($p < 0.05$) according to statistical analysis. The flakes' oil absorption capabilities ranged from 140 to 160 g/100ml. With a capacity of 160 g/100 ml, sample UZY (80:20 Maize:Mucuna) had the highest oil absorption capability, while EMU had the lowest (140 g/100 ml). The oil absorption capacity decreased with increase in *Mucuna pruriens* seed flour except for 80:20 Maize:Mucuna sample (UZY). The result has shown that the sample with 100% maize absorbed the greatest oil. The ability of food products to absorb oil increases mouth feel and flavour retention, making it a significant attribute in food compositions (Al-Okbi *et al*., 2012).

The samples swelling index values differed significantly ($p < 0.05$) and increased with increased inclusion of Mucuna seed flour in the flakes. The swelling index values were 10, 11, 12, 14 and 16 mg/g for 0, 5, 10, 15 and 20% Mucuna seed flour inclusion respectively. The increase in swelling index indicates a greater interaction between water molecules and the flour starch chain. This increase in the swelling index can partly be influenced by the processing method adopted in processing the product. In some good formulations, such as bakery products, swelling capacity is considered a quality factor. It is a factor of the ratio of α-amylose and amylopectin ratios and evidence of non-covalent interaction between molecules within starch granules (Lorenz and Collins, 2004)

The solubility power was in the range of 15 – 23 mg/g. Samples ABC, EFA, EMU, PRO, and UZY had the solubility power values of 23, 22, 21, 18, and 15, respectively. Some significant differences ($p < 0.05$) existed amongst the samples except that EFA (95:5 - Maize:Mucuna flour) and EMU (90:10 - Maize:Mucuna flour) did not differ between each other. This showed how easily the particles can get dissolved and disintegrated in water. The chemical and physical properties of the solvent and solute, as well as pressure, pH, temperature and the presence of additional chemical in the solution, all influence the solubility of a substance (Ramos *et al*., 2022).

Flour samples had bulk densities ranging from 0.5 to 0.92 g/100 ml. The samples' bulk densities differed significantly ($p < 0.05$). The lowest value (0.50) was registered by sample ABC (100:0 – Maize:Mucuna flour) while the highest value (0.92) was registered by sample UZY (80:20 – Maize:Mucuna flour). The bulk density increased with increase in *Mucuna pruriens* seed flour inclusion. The difference in bulk density could be due to variations in starch content. Starch content enhanced bulk density, according to Iwe and Onadipe (2001). This could explain why maize flour had a low bulk density in this research. Bulk density is affected by a variety of elements, including the technique of measurement, geometry, size, solid density, and surface qualities of the materials, and can be improved when the particles are small, compactible, properly tapped/vibrated and with a suitable packaging material. Bulk density refers to the relative volume of packaging material needed. The denser the packaging material, the higher the bulk density. It indicates a product's porosity, which has an impact on packaging design and can be used to determine the type of packing material required (Shrivastava, 2018).

The results of the pH showed that the flour blends for sample ABC, EFA, EMU, PRO, and UZY were more alkaline (8.00, 8.60, 8.67, 9.40, 9.40). All of the pH readings were significantly different ($p < 0.05$). The pH increased with inclusion of Mucuna seed flour making them more alkaline. On a scale of 1.0 to 14.0, pH is a measurement of the hydrogen ion concentration in water (Ramos *et al*., 2022). Many functional qualities of food, such as colour, flavour and texture are influenced by pH. Microbial development in meals is also influenced by the pH of the food. The lower the pH, the more acidic the water. The more basic or alkaline water is, the higher the pH. pH has an impact on many chemical and biological processes in water and various organisms thrive in different pH ranges (Ramos *et al*., 2022).

Sensory evaluation of Maize-based snacks complemented with *Mucuna pruriens* seed flour

The sensory scores of maize-based snacks complemented with *Mucuna pruriens* seed flour are shown in Table 3. There were significant ($p < 0.05$) variations in the colour of the samples. The snacks had mean scores ranging from 6.33 to 8.33. Except for sample ABC (100:0 – Maize:Mucuna flour) which differed from the other samples, the rest of the samples were not significantly different from each other and were within the score of 6 indicating they liked the colour slightly. With the increased inclusion of *Mucuna pruriens* seed flour, the colour of the snacks darkened and the colour scores got reduced.

Table 3: Sensory evaluation of maize-bases snacks complemented with *Mucuna pruriens* seed flour

Sample code	Maize: Mucuna	Colour	Texture	Taste	Flavour	Overall acceptability
ABC	100:0	$8.33^{a}\pm0.58$	$7.00^{a}\pm1.00$	$7.67^{a}\pm0.58$	$8.67^{a}\pm0.58$	$8.33^{a}\pm0.58$
EFA	95:5	$6.33^{b}\pm2.08$	$6.67^{a}\pm0.58$	$6.00^{ab}\pm0.00$	$7.33^{ab}\pm0.58$	$7.00^{b}\pm1.00$
EMU	90:10	$6.33^{b}\pm0.58$	$6.67^{a}\pm0.58$	$6.67^{ab}\pm1.53$	$7.00^{bc}\pm1.00$	$7.00^{b}\pm0.00$
PRO	85:15	$6.33^{b}\pm1.15$	$6.33^{a}\pm1.53$	$6.33^{ab}\pm0.58$	$5.67^{c}\pm0.58$	$6.67^{b}\pm0.58$
UZY	80:20	$6.67^{b}\pm0.58$	$6.33^{a}\pm1.53$	$5.67^{c}\pm1.15$	$7.00^{bc}\pm1.00$	$6.33^{c}\pm0.58$

Values are means ± standard deviation of triplicate results. Values in the same column with different letters are significantly different ($p < 0.05$).

This could be as a result of the oxidative conversion of the L-3,4 dihydroxyphenylalanine (L-DOPA) in *Mucuna pruriens* seed to dopamine and other oxidation products (Avoseh *et al*., 2020). Apart from sample ABC (100:0 – Maize:Mucuna flour), the dark colour of the rest of the samples overshadowed the golden brown colour that the flaking process ought to have achieved. Colour is a key parameter in evaluating the quality of flaked and baked items and ultimately influence consumers choice. Colour gives an insight on the raw materials used in the preparation and also provides information about the product's constituents, formulation and quality (Feyera, 2020).

There was no significant difference ($p < 0.05$) in the texture of the flaked snacks. The range of the scores for texture was from 6.33 - 7.00. This implied that the addition of *Mucuna pruriens* seed flour to the samples did to influence the texture quality of the snacks. Texture determines how a food snack feels (Netshishivhe *et al*., 2019). All the flaked snacks samples were crispy. The texture scores provided important and insight on the compatibility of the Maize and *Mucuna pruriens* seed flours.

The flaked snacks had significant differences ($p < 0.05$) in taste and their values ranged from 5.67 to 7.67, with the UZY (80:20 Maize:Mucuna flour) having the lowest taste score of 5.67 and the control sample (ABC; 100:0 Maize:Mucuna flour) having the highest taste of 7.67. Scores for taste reduced as the percentage of *Mucuna pruriens* seed flour increased. EFA (95:5 - Maize:Mucuna flour), EMU (90:10 - Maize:Mucuna flour) and PRO (85:15 - Maize:Mucuna flour) did not differ ($p > 0.05$) from each other. Taste has been described to be the sensation of flavour perceived in the mouth and throat caused by contact with a material and it is one of the most significant characteristics to look out for in a food product (Olurin *et al*., 2021). The taste of food products is highly dependent on the quality of ingredients used in preparing the food product.

All of the samples demonstrated a significant difference ($p < 0.05$) in flavour. They varied from 5.67 to 8.67, with the PRO (85:15 Maize:Mucuna flour) sample having the least and the control (ABC, 100 % maize) sample having the most. Apart from the control which registered the highest flavour score, sample EFA (95:5 Maize:Mucuna) blend had the second to highest score for flavour. Because EFA was the most accepted aside ABC (100% maize), it may be the finest blend for maize-based snacks fortified with *Mucuna pruriens* flour.

There were significant differences ($p < 0.05$) in the overall acceptability of the snacks. The 100% maize flour flakes (ABC – control sample) received the highest score of 8.33. Overall acceptability also decreased with increase in the inclusion of *Mucuna pruriens* seed flour and *Mucuna pruriens* substitution at a 20% level (UZY) reduced the overall acceptability from 8.33 to 6.33 ± 0.58. Aside from the control (ABC), EFA (95:5 Maize:Mucuna flour) scored second in overall acceptability of flaked snacks. Other sensory qualities were also decreased as *Mucuna pruriens* seed flour inclusion increased which has direct relationship with the overall acceptability and is comparable to the trend and relationship documented by Aminigo and Akingbala (2004).

CONCLUSION

Mucuna pruriens seed flour can be used to improve the protein content of Maize based flaked snacks. *Mucuna pruriens* seed flour inclusion in maize-based flaked snacks increase bulk density and reduce water absorption capacity of the snacks. *Mucuna pruriens* seed flour inclusion in maize-based flaked snacks darkens its colour and reduces the overall acceptability of the snacks. The best level of inclusion of *Mucuna pruriens* seed flours in maize-based flaked snacks based on overall acceptability scores is 10% (90:10 – Maize:Mucuna flour) and contains 7.20 % crude protein and 7.40 % crude fibre.

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Effects of Process Variables (Soaking Time and Drying Temperature) on Proximate Composition of Oven Dried Maize (*Zea mays*) Pap

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K E Y W O R D S

Drying temperature,
Maize pap,
Optimization,
Proximate composition,
Soaking time,

A B S T R A C T

Effect of soaking time (30 - 70 h) and drying temperature (40-100°C) on proximate composition, of oven dried maize pap were studied. Powdered pap was produced from maize. Maize grain was cleaned and soaked in water at 60°C between 30 - 70 h and wet milled, sieved and oven dried between 40 - 100°C sieved to obtain pap powder which was subjected to proximate analysis. The moisture decreased with increase in soaking time. The protein content differed significantly ($p < 0.05$), with values that ranged from 9.58-13.70 %. Ash content differed significantly (0.68 - 1.00 %), The fat content differed significantly (8.35 - 9.91 %) The crude fibre differed significantly (0.36 - 0.12 %,) carbohydrate was significantly different (65.42 - 72.4 %,) These findings suggested that varying the soaking time and oven-drying temperature significantly affected the proximate composition of the dried maize pap (Akamu) powder. The optimum conditions that would give the best product in terms of proximate composition were soaking time (34 h) and oven drying temperature (46 °C).

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INTRODUCTION

According to Adeoye and Toyin (2013) and Bolaji *et al*. (2014), traditional methods of cpap production differed and different cultures and no standardized method has been established, hence it is imparative to establish specific method. The powdered form of pap is scarce for now. Time of soaking and temperature of drying have been identified as the major processing variables that could influence dried pap qaulities (Omemu, 2011; Adeoye *et al*., 2013) The longer the soaking time, the higher the acidity (TTA) of the pap. Some researchers reported a significant difference in the viscosity as the soaking time increased, while some reported that there was no significant difference (Bolaji *et al*., 2011; Bolaji *et al*., 2017) A lot of work had been done on the nutrirtional quality , storage, rheological properties of corn pap (gruel) but little or not much reports exists on the effects of process variables on the nutritionaly properties of the gruel (Esther *et al*. ,2013; Bolaji (2014; Wasiu *et al.,* 2016.) pap (*Ogi)* is normally used as weaning and breakfast food in Nigeria for infants and adults respectively (Esther *et al*. (2013) stated that long soaking time helps not just to soften the grains but also improves the product quality, but there are nutrients losses which are significant with the long soaking period. Many studies indicated that the seed-coat and germs are where the proteins are located and they tend to leach out during the long soaking period, the fibers vitamins and ashes are affected too and have been reported. Process variables are those physical or chemical parameters or quantities that influence processes we wish to control at correct limit. The drying temperature of the wet *ogi* to powder is an important factor (Bolaji *et al*., 2014a ; Bolaji *et al*., 2016). The effect of drying temperature has been reported to increase shelf life yet can destroy the heat sensitive nutrient (Esther *et al.*, 2013). Proximate composition is a term in food science or in the field of feed /food that means the six major components of foods; Moisture, Ash, Fat, Protein, Carbohydrate, and Fibre which are expressed as the percentage (%) in the feed, respectively (Awuchi, 2019a; Awuchi *et al.,* 201914; kajihausa *et al.*,2014).

Response surface methodology (RSM) is a collection of statistical design and numerical optimization techniques used to optimize process and product design. (Ishiwu *et al.,* 2014)

The aim of this study was to determine the effect of soaking time with drying temperature on the proximate composition of powdered pap (*ogi*) from maize (*Zea mays*)

MATERIALS AND METHODS

Source of raw materials

The yellow maize (zea mays) variety was purchased from a local market, Eke- Awka in Awka south local government Area, Anambra state, Nigeria

Sample preparation

About 13 kg of the grain was divided into 13 parts with an equal weight of 1kg each. The maize was sorted, cleaned to remove extraneous materials and they were labeled accordingly and soaked differently with clean water at 60ºC, following the procedure in Table. The soaked grains were rinsed and wet-milled using attrition mill. The wet milled *ogi* was sieved using muslin cloth and a measured quantity of water (4 L) and allow to sediment for 20 min before decantation. The recovered slurry was transferred into a cloth bag and allowed to drain-off the water by expression. The drained *ogi* was weighed using a laboratory balance to get about 1 kg of each sample which was dried using oven at varying temperatures as shown in Table 1. The dried powdered *ogi* was dry-milled and sieved with standard mesh size (150 um), to obtain a fine powdered *ogi*, and was neatly packaged for proximate analysis

Experimental Design

The experimental design used was of Response surface methodology (RSM) designed in Face Centered Central Composite Design (FCCCD) with 2 independent variables (A and B as soaking time and drying temperature respectively). The design was carried out using a statistical package, Design Expert version 8.0.7.1. The levels of the process variables were established based on the some preliminary tests to arrive at Soaking time (30 – 70 h) and Drying temperature (40 -100 ºC).

Table 1: Experimental runs used in the processing of the oven dried powdered ogi.

Sample runs	soaking time (h)	Drying temperature (ºC)
1	70	70
2	50	70
3	50	70
4	30	100
5	70	40
6	70	100
7	50	70
8	50	70
9	50	70
10	50	100
11	30	40
12	30	70
13	50	40

Analyses

Proximate analysis

The proximate composition was determined using the hot oven method described by AOAC (2010)

Statistical analysis

Design Expert version 8.0.7.1 was used for the regression analysis and plotting of contour graphs

RESULTS AND DISCUSSION

The contour plot is for extrapolating soaking time and drying temperature. All in the box represents the protein content.

When the soaking time of 33 h and drying temperature of 55°C were increased to 58 h and 68°C, the protein content increased from 10 to 13%. This corroborated the report of Njintang *et al*. (2017) who reported that soaking time increased fermentation which positively may affect the value of soluble nutrients such as protein in a cereal product.

ANOVA for response surface quadratic model for fat showed that model was significant at 0.0001 levels, lack of fit is 0.0209 and R^2adj was 92.89%. These conditions qualified fat for modeling

Fat= $9.27+0.41A+ 0.37B- 0.20B^2$ ……………… Eq. 1

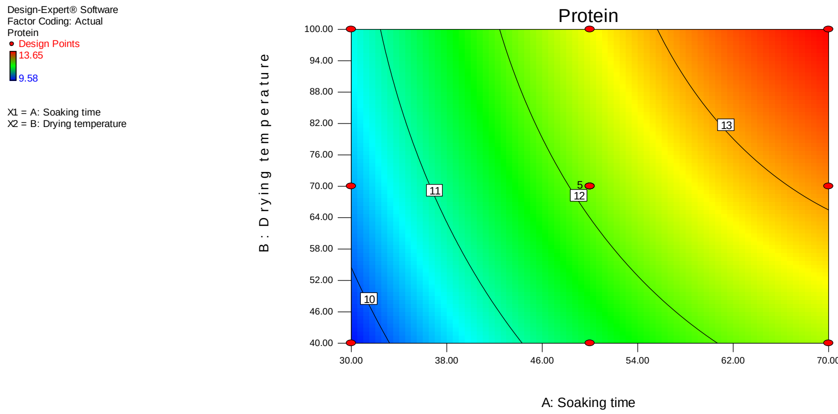

Fig. 1: Contour plot showing the effect of soaking time and drying temperature on the protein content of the *ogi* powder

From the contour plot , as the soaking time increased from about 40 to 63 h and drying temperature increased from 48 to 79 °C, the fat content increased from 8.5 to 9 %

ANOVA for response quadratic model for crude fibre showed that model for fiber was significant. Its R^2 adj was high (84.45%), Lack of fit (0.1840) was not significant.

Quadratic model was suggested as shown in Eq. 2

Fiber (%) = $0.19 – 0.078A +0.33B+0.047A^2$…………….. Eq. 2

It qualified the for fitting a response variable into a model which stated that the model has to be significant, the R^2adj. has to be high (≥60%), the lack of fit shouldn't be significant and the p-value to be included has to be significant ($p \leq 0.05$)

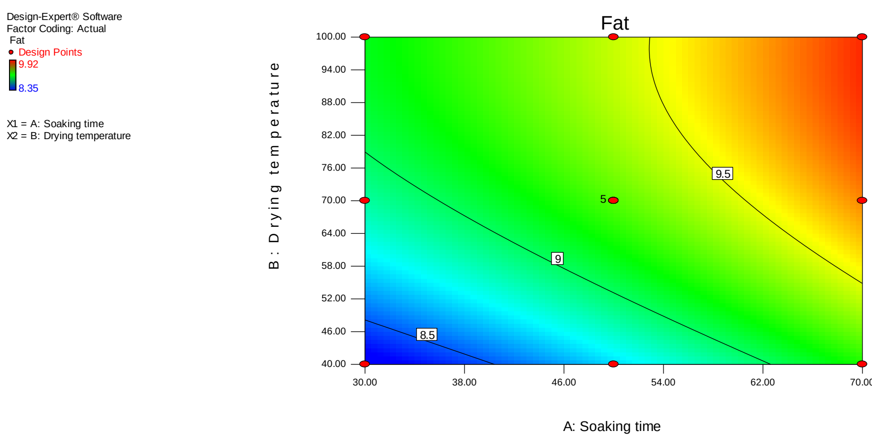

Fig. 2: Contour plot showing the effect of soaking time and drying temperature on fat content of the *ogi*

ANOVA for Response surface linear model for ash showed that the model was significant at p-value< 0.0001. The lack of fit was not significant at p = 0.2939, R^2adj = 90.3%

Crude fibre=$0.18 -0.07A +0.033B+0.052A^2+ 6.552E-003B^2$ …………….. Eqn. 3

At soaking time of 33 h and drying temperature of 88°C, the crude fibre content was 0.35%, and decreased to 30 % when the soaking time increased to 36.5% at drying temperature of 64 °C. This showed that drying temperature had appreciable effect on the crude fibre content.

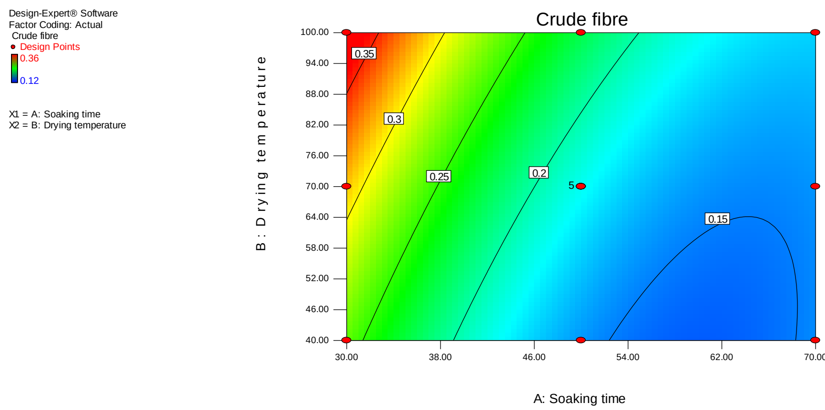

Fig. 3: Contour plot showing the effect of soaking time and drying time on the crude fibre content of the *ogi* powder.

ASH = 0.88+ 0.095A+ 0.065B …………… Eq. 4

It was seen that at the soaking time of 47 h and drying temperature of 77 °C, the ash content increased to 0.8%, while at soaking time of 63 h and drying temperature of 85°C, the ash content increased to 1 % respectively.

The effect of the process variables shows that Carbohydrate from the ogi was decreased with an increase in the soaking time but with drying temperature did not show much noticeable difference in the carbohydrate content.

The decrease in Carbohydrate could be as a result of high soaking time in which fermentation is induced, thereby leading to a reduction in the starch content.

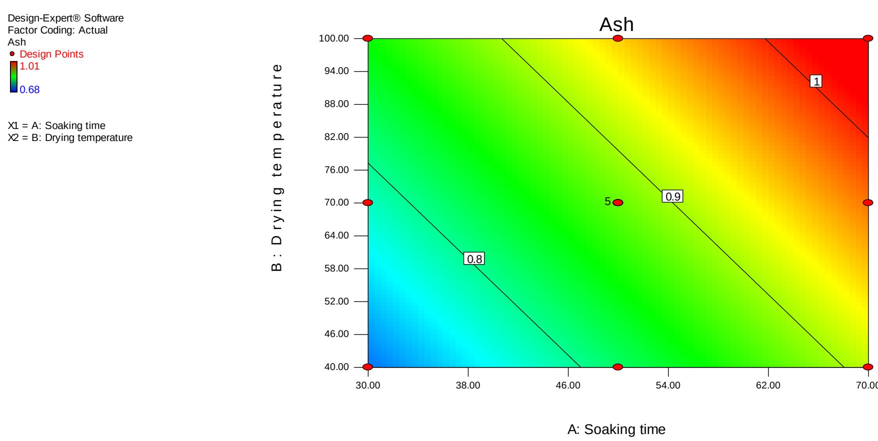

Fig. 4: Contour plot of the relationship between process variables and ash

The Figure 5 shows the predicted process variable values proximate parameter at desirability of 1.0 It shows that at soaking time of 34 h and drying temperature of 46°C, the optimized proximate composition of the ogi powder could be attained

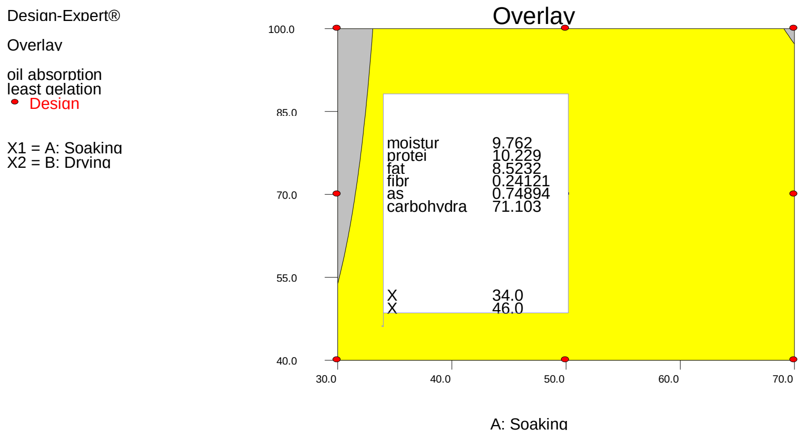

Fig. 5: Optimization plot of the proximate composition of the powdered pap

CONCLUSION

This study has revealed that soaking time and drying temperature could influence the proximate composition of oven dried maize pap (ogi)

RECOMMENDATIONS

Further studies should be carried out to investigate, the shelf stability of the oven dried pap, the nutrient density in relation to standard references and bioavailability of the important minerals

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Determination of Heavy Metals and Microbiological Contamination of Frozen Mackerel (*Scomber scombrus*) Sold in Eke-Awka Market, Awka, Anambra State, Nigeria

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KEYWORDS

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Contamination.

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ABSTRACT

The determination of heavy metals and microbiological contamination of frozen mackerel fish (Scomber scombrus) sold in Eke-Awka market were carried out on five (5) randomly obtained samples with the codes; FOV (Frozen mackerel from vendor 1), FVT (Frozen mackerel from vendor 2), FTV (Frozen mackerel from vendor 3), FVF (Frozen mackerel from vendor 4) and FFV (Frozen mackerel from vendor 5). For the heavy metals analyses, concentrations of lead in the samples ranged from 0.00 to 4.00 x 10^{-3} mg/g. Apart from sample FFV which gave 0.00, all other samples showed lead contamination higher than Codex maximum limit of 0.3 x 10^{-3} mg/g. Mercury levels ranged from 0.10 to 0.40 x 10^{-3} mg/g, which were below the permissible guideline level of 0.5 x 10^{-3} mg/g as set by Codex for fish. This suggests that all the fish samples were well below permissible levels for mercury contamination. Chromium found in samples did not exceed the recommended daily intake. Arsenic and Cadmium were not detected in any of the samples. For microbiological analysis, the total heterotrophic bacterial count ranged from 1.0 x10^2 to 3.8 x 10^2 Cfu/g, total coliform count ranged from 1.4x10^2 to 2.5x 10^2 Cfu/g, total Salmonella count ranged from 1.0 x 10^2 to 1.2 x 10^2 Cfu/g, total Vibrio count ranged from 1.0 x 10^2 to 1.5 x 10^2 Cfu/g, and total fungal count ranged from 1.0 x 10^2 to 1.5x 10^2 Cfu/g. The study showed that the frozen mackerel fish samples were heavily contaminated with microorganisms, which may be attributed to their habitat, storage conditions and poor sanitary practices employed by the vendors.

INTRODUCTION

Over the years, there has been a slow but sure decline in the populations of fish species. This has been attributed to overfishing and environmental pollution (Sikoki, 2013). These pollutants include polyaromatic hydrocarbons (PAHs), persistent organic pollutants (POPs), pesticides, metals, and recently, plastic wastes (Farrington and Takada 2014). Accordingly, the contamination of fish with pathogens and trace elements has become a major public health concern that requires constant monitoring. The food borne pathogens load in a fish product can be due to harvest environment or habitat, sanitary conditions, and practices associated with equipment and persons in the process environment (FDA, 2011). Fish can host varieties of pathogens on or inside its body as they are at the top of the food chain (Dahunsi *et al.,* 2012). Fishes are very susceptible to bacterial contamination due to their soft body organs. Use of fish as a bio-indicator of bacterial pollution can provide cumulative effect of different pollutant in the ecosystem (Santos *et al.,* 2011). Heavy metals accumulation in fish tissues depend on the concentration of the metal in the aquatic ecosystem and period of exposure (Sobhanardakani *et al*., 2011). Anthropogenic sources of heavy metals in aquatic ecosystems in Nigeria include effluents from the petroleum industry and agricultural discharge. In some cases, the concentrations of metals were found to exceed the maximum permitted levels, implying potential health risks to aquatic organisms and human consumers. Minerals (heavy metals) such as mercury, lead and cadmium are toxic even in trace amounts. However, essential minerals can also produce toxic effects at high concentrations. Industrial and municipal discharges, agricultural practices, and storm water runoff can put harmful substances into the water. Fishes absorb contaminants such as polychlorinated biphenyls (PCBs), polybrominated diphenyl ethers (PBDEs), dioxins, and chlorinated pesticides from water, sediments and the food they eat (Salwa *et al.*, 2016). Consumption of frozen mackerel fish is widespread in Nigeria as a cheaper and supposedly healthier alternative to meat protein. Considering the nutritional benefits and the attendant risks associated with fish consumption, it has become important that the microbial and heavy metal contamination of frozen mackerel fish be assessed in order to ensure that they meet the requirements of food regulations, commercial specifications (Watermann, 2002), and also the safety level for consumers.

MATERIALS AND METHODS

Source of Materials

Five samples of frozen mackerel fish were randomly purchased from Eke-Awka market, Anambra state, Nigeria. The samples were transported to the laboratory in a cooler and preserved with ice-block under complete aseptic conditions, where they were processed and analyzed for heavy metals and microbiological contamination.

Experimental Design

Five samples of frozen fish (mackerel) were drawn randomly from various vendors using a completely randomized design (CRD). Table 1 shows the five samples and codes used.

Table 1: Experimental design

S/N	Sample code	Sample description
1	FOV	Frozen mackerel fish from the first vendor
2	FVT	Frozen mackerel fish from the second vendor
3	FTV	Frozen mackerel fish from the third vendor
4	FVF	Frozen mackerel fish from the fourth vendor
5	FFV	Frozen mackerel fish from the fifth vendor

Heavy Metals Analyses

The muscle tissues of the frozen fish samples were oven dried to constant weight at 105 °C, ground into a fine powder and placed in bottles labeled accordingly. Triplicate digestion was performed according to the procedure of Turkmen and Ciminli (2007). Each of the samples was analyzed for Mercury, Arsenic, Cadmium, Lead, and Chromium by atomic absorption spectrophotometer.

Microbiological Analysis

Ten gram (10 g) of each sample of the digested frozen fish samples was put in 9ml of sterile distilled water in sterile test tubes, shaken and then serially diluted. From the appropriate dilution, 0.1 ml was inoculated separately on to MacConkey agar, Nutrient agar and Potato Dextrose agar plates and spread evenly using sterile bent glass rod. The inoculated MacConkey agar, Nutrient agar and Potato Dextrose agar plates were incubated at 30 ˚C and 35 ˚C for 24 and 48 hours respectively. After the period of incubation, the colonies on the plates were counted and recorded as colony forming unit per gram, cfu/g (Cheesebrough, 2006). Each of the bacterial colonies on the agar plates was subcultured and the pure culture obtained. The bacterial isolates were identified by carrying out tests which include; Gram staining, motility test and biochemical tests such as; catalase, coagulase, oxidase, citrate utilization and indole tests. For the fungal isolates, the pure cultures obtained were identified using morphological characteristics, spore formation, the production of fruiting body and biochemical reactions.

Statistical Analysis of Data

The data was analyzed using Statistical Package for Social Sciences version 23. All data were represented as mean of three replicates. The mean, range and standard deviation of each parameter was determined.

RESULTS AND DISCUSSION

Result of Heavy Metals Analyses from the five fish samples.

Table 2 shows the results of heavy metals in (mg/g) analyzed from the five fish samples, FOV, FFV, FTV, FVT, and FVF. The results indicate that concentrations of lead in the tissues of the fish samples ranged from 1.00 to 4.00 x 10^{-3} mg/g for FOV, FTV, FVT, and FVF, while no lead accumulation was detected in FFV. Lead concentrations in FVT and FVF were not significantly different from each other but are significantly different from the rest of the samples. Codex alimentarius commission (1995a) established maximum limit for lead contamination in fish as 0.3 mg/kg (0.3 x 10^{-3} mg/g) body weight for humans. In the present study, lead concentrations were higher than codex maximum limits. This agrees with the findings of Oluyemi and Olabanji (2011) in analysis of some heavy metals in frozen *C. harengus* and *S. scombrus* from Ibadan and Ile-Ife markets, Nigeria. The fish samples had mercury levels ranging from 0.10 to 0.40 x 10^{-3} mg/g, where FOV, FVT and FFV had no significant difference ($p > 0.05$), but were significantly different ($p < 0.05$) from FTV and FVF, which had same value of 0.10 x 10^{-3}mg/g. Mercury levels in the samples were below the permissible guideline level of 0.5 mg/kg (0.5 x 10^{-3} mg/g) as set by Codex alimentarius commission (1995a) for fish. This suggests that all the fish samples were well below permissible levels for mercury contamination. The mercury load was similar to the result of Zodape *et al*. (2011) in their work: contamination of heavy metals in seafood marketed from Vile Parle and Dadar markets of suburban areas of Mumbai (west coast of) India.

Table 2: Heavy Metals Contamination of the Five Fish Sample

Sample Code	Lead ($x10^{-3}$ mg/g)	Mercury ($x10^{-3}$ mg/g)	Chromium ($x10^{-3}$ mg/g)	Arsenic ($x10^{-3}$ mg/g)	Cadmium ($x10^{-3}$ mg/g)
FOV	$4.00^a \pm 0.00$	$0.40^a \pm 0.00$	$4.00^a \pm 0.00$	ND	ND
FVT	$2.00^b \pm 0.01$	$0.30^a \pm 0.00$	$2.00^b \pm 0.00$	ND	ND
FTV	$1.00^c \pm 0.00$	$0.10^b \pm 0.00$	$0.40^c \pm 0.00$	ND	ND
FVF	$2.00^b \pm 0.00$	$0.10^b \pm 0.00$	$0.40^c \pm 0.00$	ND	ND
FFV	ND	$0.40^a \pm 0.00$	$0.20^c \pm 0.00$	ND	ND

Values are means ± standard deviation. Means with the same superscript in the same column are not significantly different ($p \leq 0.05$). FOV = Frozen mackerel obtained from the first vendor, FVT = frozen mackerel obtained from the second vendor, FTV = frozen mackerel obtained from the third vendor, FVF = frozen mackerel obtained from the fourth vendor, and FFV = frozen mackerel obtained from the fifth vendor. ND = not detected.

The Chromium load of the samples ranged from 0.20 to 4.00 x 10^{-3} mg/g. There was no significant difference ($p > 0.05$) among FTV, FVF and FFV, but significant difference exists between them and the rest of the samples. Estimates of the daily intake ranges from 0.025 to 0.2 mg/day (Codex, 1995b). Thus Chromium found in this study may not exceed the recommended daily intake. Arsenic and Cadmium were not detected in any of the samples as they all gave the value of 0.00 x 10^{-3} mg/g for both heavy metals.

Microbiological Analysis

The results of the total heterotrophic count of bacteria on the nutrient agar are shown in Table 3. The highest number of bacterial count was obtained from FOV which was 3.8 x 10^2 Cfu/g, while the least count of 1.0 x 10^2 Cfu/g was FFV. Total *Coliform* count ranged from 1.4 x 10^2 Cfu/g to 2.5 x 10^2 Cfu/g, which was similar to the result obtained by Adebayo-Tayo *et al.* (2012) in Microbial quality of fresh fish sold in Uyo Metropolis.

Table 3: Microbiological Analysis

Sample Code	THC ($x10^2$Cfu/g)	TCC ($x10^2$Cfu/g)	TSC ($x10^2$Cfu/g)	TVC ($x10^2$Cfu/g)	TFC ($x10^2$Cfu/g)
FOV	$3.8^a \pm 0.1$	$2.3^b \pm 0.1$	NG	$1.5^a \pm 0.1$	$1.0^a \pm 0.5$
FVT	$3.5^b \pm 0.1$	$2.0^c \pm 0.1$	$1.2^a \pm 0.1$	NG	$1.5^a \pm 0.1$
FTV	$2.6^c \pm 0.1$	$2.5^a \pm 0.1$	NG	NG	$1.4^a \pm 0.1$
FVF	$2.0^d \pm 0.1$	$2.2^b \pm 0.1$	$1.3^a \pm 0.1$	$1.0^b \pm 0.1$	NG
FFV	$1.0^e \pm 0.1$	$1.4^d \pm 0.1$	$1.0^b \pm 0.1$	$1.2^b \pm 0.1$	NG

Values are means ± standard deviation. Means with the same superscript in the same column are not significantly different ($p \leq 0.05$). Where FOV = Frozen mackerel from the first vendor, FVT = frozen mackerel from the second vendor, FTV = frozen mackerel from the third vendor, FVF = frozen mackerel from the fourth vendor, FFV = frozen mackerel from the fifth vendor. THC = total heterotrophic count, TCC = total *Coliform* Count, TSC= total *Salmonella* Count, TVC = total *Vibrio* count, TFC = total Fungal count and NG = no growth observed.

The total heterotrophic count ranged from 1.0 x 10^2 Cfu/g - 3.8 x 10^2 Cfu/g, total *Salmonella* Count ranged from 1.0 x 10^2 Cfu/g - 1.3 x 10^2 Cfu/g, total *Vibrio* count ranged from 1.0 x 10^2 Cfu/g - 1.5 x 10^2 Cfu/g and total Fungal count also ranged from 1.0 x 10^2 Cfu/g - 1.5 x 10^2 Cfu/g. The highest *Vibrio* count obtained was from FOV (1.5 x 10^2 Cfu/g) while the least count obtained was from FVF (1.0 x 10^2 Cfu/g), but there was no count for FVT and FTV. Total Fungi count ranged from 1.0 x 10^2 Cfu/g - 1.4 x 10^2 Cfu/g, where FVT was the highest and FOV the lowest. From the obtained results, it can be deduced that all the samples harbored heterotrophic bacteria and *Coliform* while samples FOV and FTV were free from growth of *Salmonella*. Also, samples FVT and FTV were free from *Vibrio* growth and no fungal growth was detected for samples FVF and FFV. Arannilewa *et al.* (2006) in "effect of frozen period on the chemical, microbiological and sensory quality of frozen Tilapia fish (*Sarotherodun galiaenus*)" found that the total *coliform* count range in fish was between 3.0 x 10^3 - 7.5 x 10^6 with increasing values, as the duration of storage increases.

Morphological Identification of the Bacterial Isolates

Table 4 shows the result of morphological identification of bacterial isolates from the frozen fish samples. Gram stain of the isolated *Escherichia coli* and *Salmonella spp* was negative and the motility was positive. They were also rod shaped. *Staphylococcus aureus* was positive for gram stain and negative for motility. It had a cocci shape which is characteristic of cocci bacteria. Faecal contamination of water supplies and contaminated food handlers has frequently been implicated in outbreaks caused by *Escherichia coli* and *Salmonella spp*. These organisms have been implicated in the consumption of some acidic foods.

Table 4: Morphological Identification of the Bacterial Isolates

Isolates	**Gram stain**	**Motility**	**Shape**
Escherichia coli	-	+	Rod
Salmonella typhi	-	+	Rod
Staphylococcus aureus	+	-	Cocci

Key: Negative (-), Positive (+)

Biochemical Identification of the Bacterial Isolates

Table 5 shows the result of biochemical identification of bacterial isolates on the five fish samples. The result revealed the presence of *Escherichia coli, Salmonella spp* and *Staphylococcus aureus* in the fish samples when subjected to different biochemical tests. Catalase test was positive in the identification of all the bacteria. Coagulase test was negative for *Escherichia coli*, not tested for *Salmonella spp* and positive for *Staphylooccus aureus.* Coagulase test is used to specifically differentiate *Staphylococcus aureus* (positive) from Coagulase Negative Staphylococcus (CONS). Oxidase test was positive for *Escherichia coli* and *Salmonella spp* but negative for *Staphylococcus aureus.* Indole test was positive in the identification of *Escherichia coli* on the sample. Citrate test was negative in the identification of *Escherichia coli* and *Salmonella spp* but was positive for *Staphylococcus aureus.* The result revealed the presence of *Escherichia coli, Salmonella spp* and *Staphylococcus aureus* in the fish samples when subjected to different biochemical tests.

Table 5: Biochemical Identification of the Bacterial Isolates

Isolates	Catalase test	Coagulase test	Oxidase test	Citrate test	Indole test
E. coli	+	-	+	-	+
Salmonella spp	+	NT	+	-	-
S. aureus	+	+	-	+	-

Key: Negative (-), Positive (+), Not tested (NT).

Bacterial and Fungal Isolates from the Five Mackerel Samples

Table 6 shows that the major bacterial isolates from the samples evaluated after five days of incubation were mostly *Staphylococcus aureus, Escherichia coli, Salmonella spp, Vibrio spp, Pseudomonas spp* and *Micrococcus spp*. Major fungal isolates include: *Aspergillus niger, Penicillium spp* and *Rhizopus stolonifer.* Several studies have reported that the microbes that have been widely isolated from fish samples belong to the genera *Streptococci, Staphylococcus, Escherichia, Salmonella, Shigella, Enterobacter, Klebsiella, Serratia, Bacillus, Lactobacilli, Clostridium, Proteus, Pseudomonas, Corynebacterium, Micrococcus*, and *Aeromonas* (bacteria); *Saccharomyces, Aspergillus, Penicillin, Fusarium, Candida, Rhizopus, Geotrichum,* and *Mucor* (fungi). Results from table 6 shows that *Micrococcus spp, Pseudomonas spp, Vibrio spp, Penicillium spp* and *Aspergillus niger* appeared in all the 5 samples used in the study. Sample FOV had the highest percentage (23 %) of isolated microbes, followed by both FTV and FVF (20.5 %), and lastly by FVT and FFV (18 %). Presence of *E. coli* and *Salmonella spp* indicates possible contamination by faecal matter. Findings from this study showed that storage conditions, hygienic practices of frozen fish handlers and duration of storage may have affected the overall microbial load and contamination of the samples.

Table 6: Bacteria and Fungi isolated from frozen fish samples after 5 days of incubation.

Sample codes	*Aspergillus niger*	*Penicillium Spp*	*Rhizopus Stolonifer*	*Staphylococcus aureus*	*E. coli*	*Salmonella spp*	*Vibrio spp*	*Pseudomonas spp*	*Micrococus* spp
FOV	+	+	+	+	+	+	+	+	+
FVT	+	+	+	-	+	-	+	+	+
FTV	+	+	+	+	-	+	+	+	+
FVF	+	+	+	+	+	-	+	+	+
FFV	+	+	-	+	+	-	+	+	+

FOV = Frozen mackerel from the first vendor, FVT = frozen mackerel from the second vendor, FTV = frozen mackerel from the third vendor, FVF = frozen mackerel from the fourth vendor, FFV = frozen mackerel from the fifth vendor.

CONCLUSION

This study revealed that frozen mackerel fish sold in Eke-Awka market, Anambra State, Nigeria could be a source of heavy metals, pathogenic bacterial and fungal contamination for humans. The mercury and chromium contamination appeared to be within safe limits, while that of lead was far beyond acceptable limits. There seems to be no danger from cadmium and arsenic contamination as they were not detected. The frozen mackerel fish samples were grossly contaminated by pathogenic organisms such as: *Staphylocccocus aureus, Escherichia coli, Salmonella spp, Vibrio spp, Pseudomonas spp, Micrococcus spp, Aspergillus niger, Rhizopus stolonifer* and *Penicillum spp*., though below permissible limits, but in significant enough amounts to be of health concern. However, the absence of some of the microorganisms in some of the samples show that holding and storage conditions, period of storage and handling conditions may have contributed to the microbial contamination and load. This calls for public proper training and improvements in handling and storage conditions of frozen fish in order to minimize the frequency and extent of contamination.

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Conformability of Five Brands of Vegetable Oil Sold in Roban Stores Awka, Nigeria to NAFDAC Set Standards

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K E Y W O R D S

FFA,
Peroxide values,
Saponification value,
Specific gravity,
Vegetable oil

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A B S T R A C T

The study investigated the conformability of five brands of vegetable oil sold in Roban stores Awka to NAFDAC set standards. The oil brands used were; Sunchi soya oil (CBI), Carlini pure canola oil (ABI), Lassa vegetable oil (NEI), Golden penny pure soya oil (NMN), and Activa pure vegetable oil (JGO). The result obtained for the physical properties of the oils differed significantly ($p \leq 0.05$) and ranged from 0.65-0.92, 1.33-1.54 and 50.55-80.44 mPa・s for specific gravity, refractive index, and viscosity respectively and were below the standard set by NAFDAC for oils (0.91-0.92, 1.46-1.48) except for sample CBI with a specific gravity of 0.92 and refractive index of 1.46. However, all oil samples analyzed met the standard of ≥ 0.2 set by NAFDAC for viscosity. Furthermore, the values obtained for Saponification number, Iodine value, and Peroxide value differed significantly ($p \leq 0.05$) and ranged between 145-190 mg KOH/g, 0.90-8.86 mgI2/g and 1.70-7.48 meq/kg respectively. They complied with NAFDAC standards (190-209 mg KOH/g, 50-55 (Wijs) and ≤ 10 meq/kg). Other chemical properties analyzed were Free fatty acid, pH, Base value and impurity level. The standards of these parameters were not set by NAFDAC. Their values ranged from 3.40-6.31 mg/g KOH, 8.4-12, 8.4-12, and 0.13-0.60 respectively. The values of all parameters analyzed were within the NAFDAC recommended standard for edible oil. Thus, indicating that the oil samples studied were of good quality and suitable for consumption.

INTRODUCTION

Vegetable oils are produced from the seeds of plants that are cultivated throughout the world (Otunola *et al*., 2009). Oilseed plants, such as peanut, soybean, palm kernel, cotton, olive, sunflower, rapeseed, sesame, linseed, and safflower seeds, are important sources of lipids for human nutrition as well as for several industrial uses (Ajala and Adeleke, 2014). Vegetable oils are utilized in many different applications, including food texturizing, baking, and frying as well as in processed foods like cream and chocolate (Endo, 2017). Moreover, they are employed industrially in the production of oil paints, soap, detergent, and cosmetics (AminMir *et al*., 2014). Due to their high molecular weight and presence of unsaturated fatty acids, vegetable oils are typically favored to animal fat in terms of nutrition (Otunola *et al*., 2009).

Differences in plant sources, processing methods, physical and chemical characteristics, are some factors that may affect oil quality among brands and must be carefully considered since they can have an impact on the quality of oil-based foods (Ogah *et al*., 2020, Ceriani, *et al*., 2008; Mousavi *et al*., 2012). Colour, specific gravity, refractive index, melting point, congeal point, smoke point, flash point, fire point, and viscosity are among the physical characteristics of edible fats and oils, while their chemical properties include acid value, saponification value, iodine value, fatty acid composition, trans isomers, triacylglycerol composition, unsaponifiable matters (sterols, tocopherols), and minor components like phospholipids, chlorophyl Indexes of the deterioration of edible fats and oils include peroxide value, p-anisidine value, carbonyl value, polar molecules and polymerized triacylglycerols (Endo, 2017).

A set of standard values, guidelines and codes of practice, referred to as the "Food Code" has been adopted by the Codex Alimentarius Commission (CAC). CAC is an international food standard body established jointly by Food and Agriculture Organization (FAO) and World Health Organization (WHO) to protect the health of consumers by ensuring food safety and fair practices in food trade (Ogah *et al.*, 2020). It is a statutory obligation for food commodities in international trade to comply with these regulatory standards. In Nigeria, the National Agency for Food and Drug Administration and Control (NAFDAC) and Standard Organization of Nigeria (SON) set the standards for measuring these parameters in edible oils. So, in order to assess if commercially sold vegetable oils are suitable for consumption in accordance with these established standards, it is crucial to determine their quality and oxidative stabilities. The aim of this study was to determine the conformability of five brands of vegetable oil sold in Roban stores Awka to NAFDAC set standards.

Materials and Methods

Source of raw materials

Vegetable oil samples were purchased from Roban stores in Awka, Awka south local government of Anambra state, Nigeria.

Experimental Design

The experiment was a completely randomized design. The samples were collected in no order.

Determination of Physical Properties

The physical parameters (specific gravity, relative viscosity, colour) were carried out on the oil samples according to the method of AOCS (2016).

Determination of refractive index (RI)

The temperature of refractometer was adjusted to 40°C using circulating hot water. The Prisms were cleaned and dried. Few drops of the well mixed sample were placed on the prism, closed, and allowed to stand for 1 min. The instrument and lighting were adjusted to obtain the most distinct reading. Each sample was treated two times and average Refractive Index was recorded.

Determination of relative viscosity (RV)

Carbon dioxide from oil samples was removed by shaking gently at first and then vigorously. Temperature of the sample was kept at 30°C by using SETA KV-8 viscometer water bath. The suspending material in the oil was removed by passing the sample through a filter paper. Appropriate volume of sample was added to the kinematic viscometer which was held in a water bath at 30°C. The suction was used to draw the sample above the upper mark of kinematic viscometer and then allowed to fall. The time for the sample to pass through the upper and lower of the viscometer was measured. The analysis was carried out in duplicate to obtain the mean value of RV.

$$RV = CT \quad (1)$$

Where, T = time for flow of oil sample, C = Constant of the viscometer

Determination of specific gravity (SG)

The hydrometer was cleaned and dried. Appropriate amount of the well mixed sample was placed on suitable beaker. The hydrometer, which reads directly the specific gravity, was immersed in the beaker, and allowed to stand for 2 min. Each measurement was done in duplicates.

Determination of Chemical Parameters

Determination of iodine value (IV)

Iodine Value was determined following AOCS (2016) method. Approximately 0.25 g of the oil was measured into a 500 mL conical flask with glass stopper, to which 25 mL of carbon tetrachloride have been added. The content was mixed well. 25 mL of Wijs solution was added to the mix. The flask was covered with stopper to prevent loss of halogen by evaporation. The flask was gently swirled and stored in the dark for one hour. 20 mL of the potassium iodide solution and 150 mL of water was added. The flask was shaken and the content was titrated with standardized 0.1N Sodium thiosulphate solution, using starch as indicator. Formation of a blue colour, which disappeared after through shaking marked the end of the reaction. Blank determination was conducted in the same manner as test sample but without the oil.

$$IV = (12.69\,(B - S)\,N) / W \quad (2)$$

Where, B = volume in mL of standard sodium thiosulphate solution required for the blank, S = volume in mL of standard sodium thiosulphate solution required for the sample, N = normality of the standard sodium thiosulphate solution, W = weight in g of the sample.

Determination of acid value (AV) and free fatty acids (FFAs) contents

Acid Value was determined following AOCS (2016) method. Approximately 5 g of the oil sample was weighed into a 250 mL conical flasks and 150 mL of freshly prepared equal amount of (v/v) diethyl ether and ethanol 95% v/v were added. About 1 mL of phenolphthalein indicator solution was added. The mixture was boiled for about five minutes and was titrated while hot against standard 0.1N KOH with vigorous shaking during the titration until the end point.

FFAs as oleic acid percent by weight = 28.2VN / W (3)

AV = percent fatty acid (as oleic) x 1.99

Where V = Volume in mL of standard KOH solution, N = normality of the KOH solution, W = weight of the sample in g.

Determination of peroxide value (PV)

Peroxide Value was determined following AOCS (2016) method. Approximately 2 g of oil sample was measured accurately in 250 mL conical flask. 30 mL of solvent (20 mL acetic acid in 10 mL chloroform solution) was added and swirled to dissolve the sample. 1 mL of KI solution was added and the flask was allowed to stand for 1 min with gentle shaking. 30 mL of distilled water and few drops of starch indicator were added. Appearance of blue colour on addition of starch indicates presence of free iodine. The liberated iodine was titrated with 0.1N Sodium thiosulphate until the blue colour just vanished.

PV ($meqO_2$/Kg) = N x Vx1000/W (4)

Where; N = normality of sodium thiosulphate, V= volume of sodium thiosulphate consumed by sample in mL, W = weight of sample in g.

Determination of saponification value (SV)

Saponification value, which is the number of milligrams of potassium hydroxide required for the saponification of one gram of the test portion, was determined following AOCS (2016) method. A test portion of approximately 2 g was measured accurately in 250 mL conical flask. Exactly 25 mL of ethanolic potassium hydroxide solution was added by using burette. The flask was connected to a condenser and refluxed for one hour. The soap solution was titrated with 0.5 N HCl in the presence of phenolphthalein while it was warm. A blank determination was carried out by refluxing and titrating under the same conditions.

SV = 56.1 (B - S) N / W (5)

Where, N = normality of Hydrochloric acid, B= volume of Hydrochloric acid consumed by Blank in mL, S = volume of Hydrochloric acid consumed by sample in mL, W = weight of sample in g.

Determination of insoluble impurities (IIM)

Insoluble impurities, which are the dirt and other foreign matter, expressed as a percentage by mass, which are insoluble in n-hexane or light petroleum under the conditions specified, was determined following AOCS (2016) method. Approximately 20 g of sample was measured accurately in 250 mL conical flask. The test portion was dissolved by adding 20 mL of n-hexane in to the flask and was shaken. The solution was left for about 30 min at 30℃. Then the solution was filtered through ashless filter paper which was dried previously at 103℃ and weighed. The remaining residue on the filter paper was washed with the same solvent. The solvent remaining in it was allowed to evaporate in the open air and the evaporation was completed in the oven at 103℃. The filter paper with its vessel was removed from the oven and cooled in desiccator. The filter paper with its dried sample were measured. Two parallel determinations for each sample were carried out simultaneously to ensure that the difference between the two samples did not exceed 0.05 g of insoluble impurities per 100 g of sample.

IIM (percent by mass) = (M1 – M2) / Mo) X 100 (6)

Where, Mo = weight of test portion, M1= weight of filter paper containing dry residue, M2 = weight of filter paper.

Statistical Analysis

Results obtained from each determination are presented as mean ± SE (standard error). Tests for significance in variations was conducted by SPSS version 23.0 using Analysis of variance (ANOVA). Variations were considered significant at $p \leq 0.05$.

RESULTS AND DISCUSSION

Physical properties of the oils

The physical properties of the oil samples investigated are shown on Table 1. From the data obtained, significant differences ($p < 0.05$) were observed in refractive index, viscosity, and specific gravity values of the oil brands. The values obtained for refractive index ranged between 1.33-1.54, with sample JGO having the least value and sample ABI having the highest value. The values obtained were lower than the 1.45-1.46 set by NAFDAC and 1.44-1.47 set by JOCS. Only sample CBI with refractive index of 1.46 met the set standard. Endo (2017) reported that the refractive index of oils depends on the fats and oils variety. Palm oil has a refractive index of 1.44-1.45, while other vegetable oils have a refractive index of 1.47 at 25℃. The differences observed in the refractive index of the oils studied could be related to the source of the oil.

The values obtained for specific gravity of the oils ranged between 0.65-0.92, with sample NMN having the least value and sample CBI having the highest value. These values were below the standard set by NAFDAC for oils (0.91-0.92), except for sample CBI with a specific gravity of 0.92. The specific gravity of edible fats and oils such as corn, olive and soybean oils are in the range of 0.90-0.92 at 25℃, although palm oil and the related oil had slightly lower specific gravity 0.89-0.90）at 25℃ (Endo, 2017).

In addition, viscosity which is an index used to determine the extent of oxidation and thermal deterioration of oils was measured, and the values obtained ranged between 50.55-80.44, which were all above the standard set by NAFDAC (≥ 0.2%) and JOCS (6-10 mPa・s) at 98.9℃.

Table 1: Physical properties of investigated Oil brands

Oil brands	Refractive index	Specific gravity	Viscosity (mPa・s)
NEI	1.43^{b}±0.03	0.70^{b}±0.26	50.55^{e}±0.26
NMN	1.44^{b}±0.01	0.65^{c}±0.26	60.45^{d}±0.26
ABI	1.54^{a}±0.03	0.83^{a}±0.03	70.65^{b}±0.03
JGO	1.33^{c}±0.03	0.73^{b}±0.03	80.44^{a}±0.01
CBI	1.46^{b}±0.01	0.92^{a}±0.03	70.23^{c}±0.01
NAFDAC	1.45-1.46	0.91-0.92	≥0.2%

Results are expressed as mean ± SD. Values with the same superscript on the same column do not differ significantly at ($p \leq 0.05$). Pure canola oil= ABI; Sunchi Soya Oil= CBI; Pure vegetable Oil=JGO; Lassa vegetable oil=NEI; Golden penny oil = NMN

Chemical properties of the oils

The data obtained for the chemical properties of the oils are shown on Table.2. Significant differences ($p < 0.05$) were observed in all the parameters analyzed. The saponification values (SV) which means the average molecular weight of triacylglycerols in oils investigated in this study ranged from 145-190 mg KOH/g. The lowest and highest values were found in ABI and NEI, respectively. Only sample ABI with saponification value of 190 mg KOH/g was within the standard set by NAFDAC (190-209 mg KOH/g). Differences in the saponification values of all the samples investigated were significant at level ($p < 0.05$). The saponification values were in the order ABI>NMN>CBI>JGO>NEI. A higher SV is a measure of low-molecular weight triacylglycerols of edible fats and oils. Most vegetable oils such as corn, olive, rapeseed, and soybean oils have an SV of about 190, whereas the SV of palm oil and coconut oil, rich in palmitic acid （16:0, myristic acid （14:0）and lauric acid （12:0）is more than 200 (Endo, 2017).

Saponification value (SV) shows the extent of usefulness of the oil in soap making. It is an indication of the milligrams of KOH necessary to saponify 1g of oil sample (Odoom and Edusei, 2015). The values obtained for saponification value in this study were within the range of 5.58 - 249.90 mg KOH/g reported by Aremu *et al.* (2015) in some Nigeria oil seeds and 179.04 ± 1.60 mg KOH/g reported by Muibat *et al.* (2008) in their work on seed oil of *Telfairia occidentalis.* The result for SV showed that most of the oils studied could be used in soap making (Amoo *et al.*, 2004).

Also, a wide variation in the iodine value among the various samples of oils was observed. CBI recorded the lowest iodine value (0.90 mgI2/g) while NEI (8.86 mgI2/g) had the highest iodine value. Iodine value gives the extent of unsaturation in oil sample. It is the amount of iodine (in grams) that is required to bring about the complete saturation of 100 g of oil sample (Sanders, 2003). The iodine values of JGO (4.84 mgI2/g), NMN (4.13 mgI2/g) and ABI (4.21 mgI2/g) in this study were lower than the range of 50-55 mgI2/g set by NAFDAC and 16-23 mgI2/g reported in AOCS (2006) for palm kernel oil. The iodine values of all the oil brands investigated were lower when compared to the result reported by Muibat *et al.* (2008) in their study of seed oil of *Telfairia occidentalis* and 132.7 mgI2/g reported for soya beans oil by Aremu *et al.* (2015). The value obtained was also lower when compared to 49.10 mg I2/100g obtained in melon seed by Abdulhamid (2014). The iodine value of oil is an index for assessing the level of unsaturation and ease with which the oil can go rancid (Amoo *et al.*, 2004).

Furthermore, from Table 2, the peroxide values of the various samples analyzed ranged from 1.70 - 7.48 meq/kg and were in line with the ≤ 10 meq/kg set by NAFDAC, but lower than the 30 meq/kg set by JOCS. The highest value was found in the ABI oil while CBI oil had the least value. The peroxide value of all the oil brands tested showed significant differences ($p < 0.05$). The values were also lower than 290.00 meqO2/kg reported by Aremu *et al.* (2015), but higher than 2.26 meq/kg of seed oil of *Telfairia occidentalis* reported by Muibat *et al.* (2008). The peroxide value is used as an indicator of deterioration of oils (Endo, 2017).

In addition, the Free fatty acid (FFA), which is the percentage by weight of a specified fatty acid (Nielsen, 2014) was also measured. The edible oils had varied FFA content. This could be attributed to the variation in the refining and deodorization processes used and the moisture contents of the samples (Ong *et al*., 2009). The highest value was obtained in ABI (6.31 mg/g-KOH) and the lowest in CBI (3.40 mg/g-KOH). Free Fatty Acid values were lower for all oils and were below the standard set by NAFDAC (6.3-7.8 mg/g-KOH) for edible oils, except for sample ABI which had an FFA value of 6.31 mg/g-KOH. High levels of free fatty acids especially linoleic acids are undesirable in finished oils because they can cause off-flavours and shorten the shelf life of oils (Aremu and Amos, 2010).

The pH which is the hydrogen ion concentration of the various oils also differed significantly ($p < 0.05$) among the samples and ranged between 8.4-12. The order of increase in pH value was; CBI>JGO>NEI>ABI>NMN. The impurity level of all the oil sample were significantly different ($p < 0.05$). The base value of the oil samples (NEI, CBI and JGO) were significantly different ($p < 0.05$), while oil samples (ABI and NMN) were not significantly different ($p > 0.05$).

Table 2: Chemical properties of investigated oil brands

Properties	NEI	NMN	ABI	JGO	CBI	NAFDAC
Iodine Value (mgI2/g)	$8.86^{a}\pm0.26$	$4.13^{d}\pm0.26$	$4.21^{c}\pm0.26$	$4.84^{b}\pm0.26$	$0.90^{e}\pm0.26$	50-55
Saponification Value (mg KOH/g)	$145^{d}\pm1.00$	$180^{b}\pm1.00$	$190^{a}\pm2.65$	$170^{c}\pm2.65$	$180^{b}\pm2.65$	190-209
Peroxide Value (meq/kg)	$2.66^{d}\pm0.26$	$3.24^{c}\pm0.26$	$7.48^{a}\pm0.02$	$4.18^{b}\pm0.01$	$1.70^{e}\pm0.26$	<10 mL
Impurity Level	$0.56^{b}\pm0.03$	$0.60^{a}\pm0.03$	$0.50^{c}\pm0.03$	$0.45^{d}\pm0.01$	$0.13^{e}\pm0.01$	-
Base Value	$10^{c}\pm0.49$	$8.4^{d}\pm0.10$	$8.9^{d}\pm0.10$	$11.0^{b}\pm2.65$	$12.0^{b}\pm2.65$	-
Free fatty acid value	$4.25^{d}\pm0.01$	$5.36^{b}\pm0.01$	$6.31^{a}\pm0.03$	$4.53^{c}\pm0.26$	$3.40^{e}\pm0.26$	6.3-7.8
pH Value	$9.9^{c}\pm0.10$	$8.4^{d}\pm0.10$	$8.9^{d}\pm0.10$	$11.0^{b}\pm2.65$	$12.0^{b}\pm2.65$	6.3-8.6

Results are expressed as mean ± SD. Values with the same superscript on the same column do not differ significantly at ($p \leq 0.05$). Pure canola oil= ABI; Sunchi Soya Oil= CBI; Pure vegetable Oil=JGO; Lassa vegetable oil=NEI; Golden penny oil = NMN

CONCLUSION

In the present study, different physicochemical parameters have been examined for five edible oil samples sold and consumed within Awka Metropolis. The physical properties of the various brands of oils investigated in this study did differ significantly ($p \leq 0.05$). The wide variations among their chemical properties account for the differences in their compositions. Their physicochemical properties as obtained in this study showed that they are all suitable for consumption as they are within the permissible ranges set by NAFDAC.

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Physicochemical and Sensory Attributes of Breakfast Food from Blends of *Ipomoea batatas* and *Sphenostylis stenocarpa* Flours

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K E Y W O R D S

African yam bean,
Flake,
Orange fleshed sweet potato

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A B S T R A C T

The research was carried out to produce flakes from blends of Orange fleshed sweet potato (OFSP) and African yam bean (AYB) and determine its proximate, functional, vitamin, anti-nutrient and sensory properties. The different flours were mixed at different ratios of 75:25, 50:50, 0:100, 100:0, 50:50, 25:75, 100:0, and 0:100, for OFSP and AYB respectively and used to produce flakes. Analysis was carried out using standard procedures. There was significant difference in the properties of all the eight blended samples of flour. The proximate composition (%) of flake showed that crude fibre content ranged from (1.64 - 2.31), moisture content (6.41- 7.18), ash content (2.16 - 3.41), protein content (9.69 - 21.23), carbohydrate content (64.73 - 78.71) and fat content (1.15 - 1.84). The functional properties bulk density, water absorption capacity, oil absorption capacity and breaking strength of the flakes differed significantly (p< 0.05) The vitamin A and hydrogen cyanide of the sample also differed significantly (p < 0.05) The result showed that sample 6 (25 OFSP and 75 AYB), 3 (0 OFSP and100AYB) and 8 (0 OFSP and100 AYB) produced the most acceptable flake and could be recommended.

INTRODUCTION

Flake, can be known to be small, flat, very thin pieces of food products which can be used as breakfast (Kadan and Caldwell, 2003). Sharma and Caralli., (2004) stated that breakfast cereal are foods obtained by swelling, grinding, rolling or flaking of any cereal. Ready-to-eat breakfast cereals are increasingly gaining acceptance in most developing countries, and gradually displacing most traditional diets that serve as breakfast due to convenience, nutritional values, improved income, and status symbol and job demands (Edima-Nyah *et al*., 2019). The common cereal products in Nigeria include Nasco Cornflakes, Good morning corn flakes, Kellogg's cornflakes, Nabisco flakes, Weetabix, Quaker Oats, Rice crisps.

African yam bean belongs to the family: *Fabaceae* (alt. Leguminosae) subfamily: *Faboideae* tribe: *Phaseoleae* subtribe: *Phaseolinae.*, also placed in: *Papilionaceae*, genus *Sphenostylis.* African yam bean (AYB) seeds can be brown, white, speckled or marbled with a hilum having a dark-brown border (Ikhajiagbe and Mensah, 2012). The Igbo people of the south eastern Nigeria call it "Okpodudu, Ijiriji, Azama" and the seeds may be boiled and eaten with local seasoning, starchy roots, tubers. The seeds can also be toasted and eaten with palm kernels (Enwere, 1998).African yam bean (AYB), is known to have a nutritive and culinary value, which has brought it into focus to previous workers as (Agunbiade and Ojezele, (2010) Abbey *et al.* (1991) evaluated the functional properties of African yam bean flour. Orange fleshed sweet potato (OFSP) is a bio-fortified sweet potato, it is a new crop that has been introduced due to its high beta-carotene, which is an organic, red-orange pigment abundant in plants and fruits (Ukoma, *et al*., 2019). Beta-carotene is what gives OFSP an orange colour and is converted to vitamin A in the after consumption to provide additional nutritional benefits (Edima-Nyah , 2019).

Thus, the aim of this work was to produce breakfast cereal in form of flake from blended flours of African yam bean and orange fleshed potatoes. The specific objectives were to evaluate its proximate, physical and sensory properties and drive the optimum blend ratio for the product.

MATERIALS AND METHODS

Source of raw materials

Mature *Ipomoea batatas* (orange fleshed sweet potatoes) was purchased from Zodok farms limited, Yenagoa, Bayelsa state, Nigeria and *Sphenostylis stenocarpa* (African yam bean) was purchased from new market, Enugu State, Nigeria.

Preparations of raw materials

Production of OFSP flour (Carrot C)

The OFSP flour was produced according to Kulkarni *et al.* (1988) with little modification. The freshly harvested potatoes (Carrot C) was sorted washed, brushed and peeled. The eyes and all bruises were pitted out. Immediately after the peeling, the potatoes were sliced and put into a container. Portable water that boiled at 100°C was poured into the container containing the sliced potatoes and left for 3 minutes, drained and uniformly layered in a tray and dried at a temperature of 75 °C in a hot air cabinet drier for 15 h. The dried potatoes were milled and sieved through the 1mm mesh sieve. The potato flour was packed in air-tight containers

Production of African yam bean flour (AYB)

The procedure described by (Enwere, 1998) was used with little modification. The African yam bean was cleaned, sorted, weighed and washed thoroughly with clean running tap water after which it was soaked in water for 12 hours at room temperature and boiled for 30 minutes. The boiled African yam beans was dried in a hot air oven at 60°C for 10 hours, dehulled and milled using an attrition mill. The flour obtained was sieved and packaged in polyethylene bags for further analysis. The flow diagram for the production of African yam bean flour

Production from the blends of orange fleshed sweet potato flour and African yam bean flour

The blend of OFSP and AYB flour was used to produce the flakes according to Banjoko *et al*. (2019) with little modification. Potable water (100 ml) was added and mixed thoroughly to produce slurry. Foils were placed on baking pan and the slurry poured on it evenly. It was oven baked at 150 ℃ for 30 min and cooled.

Experimental design

The experiment is a Completely Randomized Design

Table 1 shows the blend ratios of the OFSP and AYB flours used in the production of the flakes

Table 1: Experimental design

OFSP (%)		AYB (%)
1	75	25
2	50	50
3	0	100
4	100	0
5	50	50
6	25	75
7	100	0
8	0	100

Analyses

Proximate composition

Proximate composition was determined according to the standard methods of Association of Official Analytical Chemists (AOAC, 2010).

Physical properties

The bulk density and water absorption capacity were determined according to the methods described by Onwuka (2018). The breaking strength was determined according to the method described by Okaka and Isiehs (1997).

Sensory Attributes

Sensory properties were determined using 9 point Hedonic scale were 9 = like extremely and 1 = dislike extremely (Ishiwu and Onyeji, 2004)

Statistical analysis

The scores obtained were subjected to a one-way Analysis of Variance (ANOVA) version 23. The Least Significant Difference (LSD) test and Duncan Multiple Range Tests were used to determine significant differences between means and separate means respectively at $p < 0.05$ levels using SPSS package version 17.0.

RESULTS AND DISCUSSION

Proximate composition of the sample

The proximate composition of the flake is represented in Table 2. The moisture content of the samples ranged from 7.18 - 6.52 %. From the results, there was no significant difference ($p > 0.05$) in the moisture content of the samples. A low level of moisture content in products helps to prohibit the growth of bacterial in the food product thereby increasing its shelf life (Ishiwu and Onyeji, 2004; Adebowale *et al*., 2014)

The protein content of the samples ranged from 9.69 - 21.23%. There were significant differences ($p < 0.05$) among the samples. The protein content obtained were higher than protein content reported on breakfast cereal from rice. Protein helps to boost metabolism and increase muscle mass and strength (Okoronkwo *et al*., 2019)

The ash content of the samples which is a measure of mineral element ranged from 2.16 - 3.41% in the flakes. There was no significant difference ($p > 0.05$) between. The high ash content implies high amount of mineral in the samples provided there wasn't any contamination of the samples by foreign matters (Ishiwu and Onyeji, 2004). Adebanjo *et al*. (2020) worked on extruded flakes from pearl millet and carrot blended flour production and reported higher ash content of 1.19-2.97%. among the samples. The fat content of the samples ranged from 1.15 - 1.84%. There was no significant difference among the samples ($p > 0.05$) in the fat content of the samples. The crude fibre content of the samples ranged from 1.64 - 2.31%. There was significant difference ($p < 0.05$) in the crude fibre among the samples. Fibre would help to boost the health, normalize bowel movement when ingested (Adebanjo *et al*., 2020).

The carbohydrate content of the flake samples ranged from 64.73 - 78.71%. There was significant difference ($p < 0.05$) in carbohydrate between the samples.

Physical properties of the flake samples

The analyzed data for functional properties for all the samples are presented in Table 3. The bulk density appreciably increased from 0.63 to 0.83 g/cm^3. This result indicated that BD increased with increased substitution of OFSP flour.

Table 2: Proximate Composition (%) of the Flake Sample

Sample	Moisture	Protein	Ash	Fat	C. fibre	CHO
1	$6.63^a \pm 0.35$	$12.56^d \pm 0.06$	$2.46^d \pm 0.01$	$1.35^d \pm 0.01$	$1.80^d \pm 0.01$	$75.21^b \pm 0.06$
2	$7.18^a \pm 0.74$	$14.69^c \pm 0.04$	$2.76^c \pm 0.01$	$1.49^c \pm 0.07$	$1.96^c \pm 0.07$	$71.91^c \pm 0.62$
3	$6.52^a \pm 0.42$	$21.25^a \pm 0.02$	$3.41^a \pm 0.21$	$1.86^a \pm 0.14$	$2.31^a \pm 0.07$	$64.73^e \pm 0.04$
4	$6.65^a \pm 0.42$	$9.69 \pm ^e 0.21$	$2.16^e \pm 0.01$	$1.15^e \pm 0.01$	$1.64^e \pm 0.00$	$78.71^a \pm 0.00$
5	$7.18^a \pm 0.74$	$14.69^c \pm 0.04$	$2.76^c \pm 0.01$	$1.49^c \pm 0.07$	$1.96^c \pm 0.07$	$71.91^c \pm 0.62$
6	$6.58^a \pm 0.28$	$18.26^b \pm 0.01$	$3.07^b \pm 0.03$	$1.61^b \pm 0.01$	$2.15^b \pm 0.01$	$68.34^d \pm 0.01$
7	$6.65^a \pm 0.42$	$9.69^e \pm 0.21$	$2.16^e \pm 0.01$	$1.15^e \pm 0.01$	$1.64^e \pm 0.00$	$78.71^a \pm 0.00$
8	$6.52^a \pm 0.42$	$21.25^a \pm 0.02$	$3.41^a \pm 0.21$	$1.86^a \pm 0.14$	$2.31^a \pm 0.07$	$64.73^e \pm 0.04$

Values represented as mean ± standard deviation. Means with different superscripts in the same column are significantly different (p <0. 05).

Low bulk density can be beneficial in formulation of infant foods since small quantity will be required to obtain desired bulkiness of food products (Suresh, 2013).

Water absorption capacity indicates the ability of flour to reconstitute under limited water conditions (Suresh, 2013). Values of the Water absorption capacity (WAC) ranged from 2.97 to 3.55 ml/g. Water absorption capacity would be affected by the granule structure of the blended flours caused by the starch fractions of amylose and amylopectin molecules. Heat treatment of the product could have dissociated the protein into smaller subunits making it have more binding capacity for water.

The tensile strength or breaking strength ranged from 50.00 to 98.53g.. Significant difference ($p < 0.05$) existed between samples. Breaking strength mostly called tensile strength is maximum load that a material can support without fracture when being stretched, divided by the original cross-sectional area of the material (Britannica, 2021). The result showed that the samples with a lower breaking strength are more crunchy and easier to chew than the samples with higher breaking strength.

Sensory properties of the flakes

The mean score of the sensory attribute of flaked samples is presented in Table 3.

Table 4: Sensory Properties (%) of Flaked Samples

S/N	App	Aroma	Taste	Cr	Mouth F	Gen Accep
1	$3.40^{e}\pm1.23$	$3.72^{f}\pm0.98$	$3.76^{d}\pm1.27$	$4.16^{c}\pm1.14$	$3.80^{e}\pm1.26$	$3.96^{e}\pm1.21$
2	$4.48^{d}\pm1.36$	$4.04^{ef}\pm1.04$	$4.16^{cd}\pm0.175$	$4.40^{c}\pm1.85$	$4.08^{de}\pm1.51$	$4.68^{de}\pm1.60$
3	$7.04^{b}\pm0.58$	$7.28^{ab}\pm0.61$	$7.52^{a}\pm0.59$	$7.36^{a}\pm0.76$	$7.04^{b}\pm1.37$	$7.52^{b}\pm0.96$
4	$4.92^{d}\pm1.66$	$4.60^{de}\pm1.76$	$4.24^{cd}\pm1.79$	$4.84^{c}\pm1.99$	$4.20^{e}\pm1.56$	$4.68^{de}\pm1.89$
5	$4.52^{d}\pm1.23$	$4.04^{ef}\pm1.27$	$3.96^{d}\pm1.134$	$4.56^{d}\pm1.76$	$7.16^{b}\pm0.85$	$4.60^{de}\pm1.41$
6	$7.52^{bc}\pm0.94$	$6.96^{b}\pm0.61$	$7.16^{a}\pm0.75$	$7.44^{a}\pm1.12$	$7.04^{b}\pm0.84$	$7.44^{b}\pm0.87$
7	$5.04^{d}\pm1.57$	$4.88^{d}\pm1.72$	$4.88^{c}\pm1.61$	$5.04^{c}\pm1.65$	$4.00^{de}\pm1.32$	$5.12^{d}\pm1.79$
8	$6.76^{c}\pm1.59$	$5.96^{c}\pm2.03$	$6.16^{b}\pm2.08$	$6.24^{b}\pm1.91$	$6.00^{c}\pm2.04$	$5.96^{c}\pm2.28$
9	$8.56^{a}\pm0.71$	$7.96^{a}\pm1.02$	$7.52^{a}\pm1.45$	$7.68^{a}\pm0.95$	$7.92^{a}\pm0.76$	$8.56^{a}\pm0.77$

Values represented as mean ± standard deviation. Means with different superscripts in the column are significantly different ($p < 0.05$) suggesting a high interpretation that the model is a

Table 3: Physical properties of the flake

Sample	Bulk density (g/cm^3)	Water absorption (ml/g)	Breaking strength (g)
1	$0.81^{b}\pm0.01$	$3.05^{b}\pm0.01$	$97.93^{a}\pm0.18$
2	$0.77^{c}\pm0.00$	$3.03^{bc}\pm0.01$	$98.53^{a}\pm0.04$
3	$0.68^{e}\pm0.00$	$2.97^{d}\pm0.01$	$51.06^{a}\pm72.20$
4	$0.83^{a}\pm0.00$	$3.55^{a}\pm0.01$	$96.61^{a}\pm0.15$
5	$0.77^{c}\pm0.00$	$3.03^{bc}\pm0.01$	$98.53^{a}\pm0.04$
6	$0.73^{d}\pm0.00$	$2.98^{cd}\pm0.43$	$50.00^{a}\pm70.72$
7	$0.83^{a}\pm0.00$	$3.55^{a}\pm0.01$	$96.61^{a}\pm0.15$
8	$0.68^{e}\pm0.00$	$2.97^{d}\pm0.01$	$51.06^{a}\pm72.20$

Values represented as mean ± standard deviation. Means with different superscripts in the same column are significantly different ($p < 0.05$)

Appearance is an important sensory attribute of any food because it influences the acceptability of the product. There were significant differences ($p < 0.05$) among the samples in appearance which is an important attribute to consumer's true representation of the relationship between the orange fleshed sweet potato and African yam bean

CONCLUSION

The flakes had high carbohydrate and protein content, the tensile strength of sample (50 OFSP: 50 AYB) and (was higher, and sample 3 was high in overall acceptability and aroma. Samples 6 (25 OFSP : 75AYB), 3 (0 OFSP:100AYB) were most acceptable and could be recommended.

RECOMMENDATION

It is recommended that further experimental investigation geared towards ascertaining the mineral quality, microbial load, shelf stability of the flakes be investigated

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Performances of Riverine and Upland Accessions of Fluted Pumpkin in Awka Rain Forest Zone of Nigeria

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ABSTRACT

An across geographical zone experiment was conducted to compare the performance of a riverine telferia accession with an upland land race in Awka. Both accessions seeds for planting were relatively of the same size and weight. At 21 days after planting, 77% of the riverine seeds emerged as against 72% of the local race. The Randomized Complete Block Design (RCBD) Experiment consisted of Upland and Riverine telferia accessions whole seeds as the treatments. They were each planted ten seeds on 4x1m beds (plots) and replicated five times. The riverine accession also produced more leaves, and longer vines at WAP1 and 2 before the two accessions leaf numbers and stem lengths became equal. The probable cause of its early start and better performance might be due to higher soil and environmental temperatures when compared with the relatively lower soil temperatures common in the riverine environment. The riverine accession also had the biggest vine girth and larger leaf area which accounted for its higher vine and leaf harvest at WAP 4 (213.70kg/ha) and WAP11 (4.00t/ha) as against upland accession WAP4 (77kg/kg) and WAP11 (2.68t/ha) harvests. Riverine accession started flowering early at 13 WAP (91 days), while upland accession started at 14 WAP (98days). Riverine accession also started fruiting at 16 WAP (112 days), while upland accession started fruiting at 23 WAP (161 days). Therefore, to achieve maximum production of telferia in Awka rainforest zone of Nigeria, riverine accession is recommended.

INTRODUCTION

Telfairia occidentalis belongs to the Cucurbitaceae family, and its is an indigenous vegetable consumed by millions of people in Nigeria(Ifeoma *et al*., 2008).Fluted pumpkin is an important leaf and seed vegetable indigenous to Southern Nigeria and is grown in the forest zone of west and central Africa such as Nigeria, Ghana and Sierra Leone being the major producers (Chukwudi *et al*., 2017). It is an important vegetable crop that has high nutritional and commercial value (Schippers, 2000) The leaves are palatable, nutritious and are used in soups and porridges as the vegetative parts of the crop make an excellent vegetable which is very rich in vitamin and has 37.3% protein content on a dry weight basis (Schippers, 2002). The leaves of fluted pumpkin have medicinal values and are used for the treatment of anaemia and diabetes (Akanbi*et al.,* 2007,Odiaka*et al.,* 2008; Chukwudi and Agbo, 2014b). The seed contains 20% protein, 45% fat, 23% carbohydrate, 2.2% fibres and 1.8% total ash. The oil in the seeds is non-drying and it contains lactating properties which are of high demand by nursing mothers (Akanbi*et al.*, 2007). The *Telfairia occidentalis* ranks highest, in terms of net income (Chukwudi and Agbo, 2014b), among the notable and common tropical leafy vegetables (TLVs) grown in South-eastern Nigeria. Frequent cutting interval of *Telferia occidentalis* is used when leaf is the desired yield, while less cutting frequency is more adequate for higher fruit yield (Chukwudi and Agbo, 2014a).). The female plants are endowed with large succulent leaves while the male plants produce leaves that are scrawny, small and less attractive.High yield is the major objectives of breeders and growers over the recent decades (Wang and Li, 2008; Xing and Zhang, 2010). Yield is a complex character which is also a function of several component traits and their interaction with environment (Iqbal *et al.,* 2013). The prevailing global climate change is making a great impact on the world climatic conditions, and because of this effect, it is more difficult to predict weather condition for accurate and successful annual farming (Ibrahim *et al.,* 2013; Carns*et al*., 2013; Olaoye and Rotimi, 2010,Lin *et al*., 2020). Soil and air temperatures have effects on many aspects of crop growth and development, such as leaf growth and expansion and are all correlated

(QiJin and GuangSheng, 2012; Lamidi, 2009.The phenotype of an individual is determined by the effects of its genotypes, the environment, and the interaction between the genotype of the individual and the environment. Genotype x environmental interaction is a prerequisite for crop plant improvement and evaluates the improved genotypes across multiple environments (locations and years), before they are promoted for release and commercialization.The differential response of cultivars to diverse environments is referred to as a crossover interaction when cultivar ranks change from one environment to another. Therefore, the objectives of this study is to: Compare the agronomic and yield performances of Riverine and Upland accession of *Telferia occidentalis* in Awka and evaluate the returns of growing the two *Telferia occidentalis* accessions in Awka.

MATERIALS AND METHODS

Experimental site:

The experiment was conducted at the Teaching and Research Farm of Crop Science and Horticulture Nnamdi Azikiwe University, Awka, Anambra State Nigeria. Awka is characterized by tropical rain forest with temperature between 27^0C - 30^0C. The research farm lies on latitude 6.2497N and 7.1167E and annual seasonal rainfall of 1828mm.

The Experimental Materials

Upland telferia accession seeds (ụgụelụ ala) are the normal telferia that are grown in the Rain Forest Zone of Nigeria and were bought from Eke Awka Market, Awka, Anambra state. The leaves are relatively light green in colour and small in size, the fruits are plump in size. Riverine telferia accession seeds (ụgụ ala mmiri) are the common land race telferia that are grown in the High Rain Forest and Swampy Zones of Nigeria and were bought from Rumuokoro Market, Obio/Akpor ,Rivers State.The leaves are relatively deep green in colour and large in size,the fruits are long and large in size.

Experimental Design

The Randomized Complete Block Design (RCBD) Experiment consisted of Upland and Riverine telferia accessions whole seeds as the treatments. They were each planted ten seeds on 4x1m beds (plots) and replicated five times. This gave ten plots and experimental field that measured 9 m x7 m including the walk ways.

Cultural practices*:* Land clearing was done manually using cutlass. A land area of 25m× 25m was mapped out for the field experiment. The seeds were planted at 1x1meter spacing on 1x3 meter beds. Wet poultry manure was used as source of soil nutrients and was applied at the rate of 1kg/hole. They were applied to the soil before seeds were sown. Staking were done using raised 1.5m high horizontal plate forms per bed. It was done on randomized complete block design (RCBD).

Data collection and analysis *:*The growth parameters measured were, plant height(cm), stem girth(cm^2), number of leaves, number of tendrils and leaf area(cm^2).vine length (cm) and number of branches. Data collected on yield include; number of fresh fruits, fruit size (cm^2), and weight of fresh fruits (g) .The growth data collection was done on a weekly basis while harvesting of leaves were done once every 21 days .All the data collected were subjected to analysis of variance (ANOVA) following the procedures for the experiment in Randomized complete block design (RCBD) using GENSTAT (2012) statistical software package. Mean separation was done by using least significant difference (LSD) at 5% probability level.

Results

The influence of location on the *Telferia* accessions seeds emergence (%).The result on table1 showed the weights of the Telferia seeds (g). Although the Riverine accessions seeds appeared bigger in size, they did not significantly differ from upland accession seeds. On the influence of location on the Telferia accessions seeds emergence (%) at 21 and 28 DAP. It was discovered that 77% Riverine accession seeds emerged at 21days while 72% upland accession emerged ,although both seeds emergence were not significantly different at 28 DAP (83%).

Table 1: The influence of location on the Telferia accessions seeds emergence (%)

	Weight per seed (g)	**Emergence%**			
Accession		DAP 21	%	DAP 28	%
Upland	16.40	13.00	72	15.00	83
Riverine	19.50	14.00	77	15.00	83
$LSD_{0.05}$	Ns	0.20		Ns	

NS: Non significant

Influence of location on the Telferia accessions number of leaves

Table2: Displayed the influence of location on *Telferia* accessions number of leaves, it was observed that the Riverine accession had more leaves at WAP1 (6.50), WAP 2 (7.75) and WAP 4(13.50). The leaf number later became the same until WAP10 during which the upland accession scored (24.50) as against Riverine accession (20.75).

Table 2: **Influence of location on the Telferia accessions number of leaves**

	Weeks after Planting									
Accession	1	2	3	4	5	6	7	8	9	10
Upland	4.75	6.25	9.75	11.75	13.25	14.50	16.50	18.00	20.25	24.50
Riverine	6.50	7.75	11.50	13.50	14.00	15.00	18.75	18.00	19.50	20.75
$LSD_{0.05}$	0.93	0.90	ns	1.70	ns	ns	ns	ns	ns	3.30

Table 3 showed the influence of location on the *Telferia* accessions stem girth (cm^2). From the result, it was deduced that the two *Telferia* accessions stem girths were not significantly different till 7 WAP. The stem girths of the Riverine accessions were bigger from WAP7 (9.88 cm^2) up till 10 WAP when it was (13.00 cm^2) as against (10.00 cm^2) of upland accession.

Table 3: Influence of location the *Telferia* accessions on stem girth (cm^2).

	Weeks after planting						
Accession	4	5	6	7	8	9	10
Upland	6.00	6.50	7.08	7.50	8.25	8.50	10.00
Riverine	5.50	6.65	8.25	9.88	11.38	12.38	13.00
$LSD_{0.05}$	1.22	1.16	1.96	2.20	2.20	2.40	2.50

Influence of location on the *Telferia* accessions main stem length (cm)

After WAP 1and 2, it was observed that the riverine accession main stem length was significantly longer than that of the upland accession. At WAP 10 upland accession was (147.70cm) while the riverine accession was (164.70cm). (Table 4)

Table 4: Influence of location on the *Telferia* accessions main stem length (cm)

	Weeks after planting									
Accession	1	2	3	4	5	6	7	8	9	10
Upland	14.33	25.00	38.50	52.70	67.00	81.20	98.30	107.00	115.00	147.70
Riverine	14.67	25.00	44.30	80.00	98.80	118.80	123.00	135.70	152.00	164.70
$LSD_{0.05}$	2.00	3.72	5.66	10.45	10.83	8.60	8.34	8.75	11.18	13.00

I

Influence of location on the *Telferia* accessions leaf area (cm^2)

Table 5,showed the influence of location on the *Telferia* accessions leaf area (cm^2) .The Riverine accession leaf area were observed to be larger than that of the upland accession throughout the course of the work like at WAP10,it was (425.00 cm^2) as against (312.00 cm^2) of the upland accession.

Table 5: Influence of location on the *Telferia* accessions leaf area (cm^2)

Accession	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Upland	37.50	55.50	89.50	112.90	136.00	212.00	238.00	256.00	308.00	312.00
Riverine	40.50	74.80	126.70	200.20	240.00	269.00	278.00	309.00	363.00	425.00
$LSD_{0.05}$	14.5	18.60	30.80	72.40	86.40	108.50	Ns (114)	100	84.3.00	115.70

Influence of location on the *Telferia* accessions marketable weights and harvest returns.

Table 6: showed the influence of location on the *Telferia* accessions marketable weights (leaves and stems)(g) at 4 and 11 WAP. The research showed that the first harvest was done at 4 WAP with the upland accession yielding (7.70 grams) per plant, that was an equivalent of 77 kg/ha and Riverine accession yielding (21.37 grams) per plant, that was an equivalent of 213.70 kg/ha. The second harvest at 11 WAP of riverine accession yielded an equivalent of 4.06 t/ha, which was significantly higher than that of upland accession (2.68 t/ha). Presently, a typical head of telferia (consists of leaves and stem unit for sale) in the market that weighs about 20grams costs ₦100:00 and so the upland accession yield of 77.00kg/ha would sold at ₦385,00:00 while that of Riverine accession at 213.70kg/ha would sold at ₦1,070,000:00.

Table 6: Influence of location on the *Telferia* accessions marketable weights and harvest returns.

Accession	WAP 4 (g/plant)	WAP 11 (g/plant)	Average (kg/ha)	Yield per hectare (t/ha)	WAP 4 hst (stem and leaves) returns
Upland	7.70	268.00	77.00	2.68	₦385,000
Riverine	21.37	406.00	213.70	4.06	₦1,070,000
$LSD_{0.05}$	8.01	70.40			

DISCUSSION

The experiment was conducted to compare the performance of a riverine telferia accession with an upland land race in Awka. Environmental factors that affect plant growth include light, temperature, water, humidity, and nutrition. It is important to understand how these factors affect plant growth and development (Geiger and Todhunter (2003).Both accessions seeds for planting were relatively of the same size and weight. The riverine accession also produced more leaves, and longer stems at WAP1 and 2 before the two accessions leaf number became equal. The probable cause of its early start and better performance might be due to high soil and environmental temperatures' especially as the nutrient supply were the same for the accessions. Temperature influences most plant processes, including photosynthesis, transpiration, respiration, germination, and flowering (Geiger and Todhunter (2003).As temperature increases (up to a point), photosynthesis, transpiration, and respiration increase. When combined with day-length, temperature also affects the change from vegetative (leafy) to reproductive (flowering) growth (Nwankwo and Oguguru,2012). It should also be noted that riverine accession also had the biggest stem girth and larger leaf area throughout the course of the work and this was the reason for its higher stem and leaf harvest at WAP 4 (213.70kg/ha) and WAP11(4.00t/ha) as against upland accession WAP4(77kg/kg) and WAP11(2.68t/ha)harvests. Presently, a typical head of telferia (consists of leaves and stem unit for sale) in the market that weighs about 20grams costs ₦100:00 and so the upland accession yield of 77.00kg/ha would sold at ₦385,00:00 while that of Riverine accession at 213.70kg/ha would sold at ₦1,070,000:00.

The leaf area (cm^2) of *Telferia occidentalis* is very important, as it acts as an indicator when it comes to photosynthetic capacity.This is in accord with the findings of Ojeifo*et al., (*2006)that cultivation of *Telferia occidentalis* for its leaf or fruit, or both, is a profitable enterprise.Chukwudi and Agbo, (2014b) also stated that the higher number of leaves per plant was pivotal to high leaves and fruit quality and quantity as more photosynthetic activities took place on the leaf surface resulting in more translocation of photosynthates to the leaves, fruits and other storage organs. The leaves of *Telferia occidentalis* is very nutritional, consumers always desires to get the ones with good number of leaves, and is more marketable (Odiaka*et al.,* 2008;) It is very clear that the more the stem of fluted pumpkin, the more leaves that will be generated as well, and this is in conformity with the findings of (Odiyi *et al.,* 2014) who indicated that number of stem, can as well influence number of leaves which is very important in determining the marketable leaf yield of fluted pumpkinFlowering in fluted pumpkin is very essential, and that will usher in the fruit development. According to Odiaka and Akoroda (2009) female plants commenced flowering from 105 to 141 days after sowing. AlsoAkoroda and Adejoro (1990) recorded as well that female and male plants took about 150 and 129 days, respectively to flower. The Riverine accession performed better than the upland accession in most of the tested parameters .The experiment indicated that the Riverine accession produced a good number of leaves and long stems, bigger stem girth and leaf area and also had early flowering and fruiting potentials.(Porfirio *et al.,* 2018).So there is need to check the productivity of local crops accessions across different geographical locations to ascertain their adaptability and productivity. Therefore, to achieve maximum production of *Telferia occidentalis* inAwka rainforest zone of Nigeria, Riverine accession is recommended.

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Biochemical and Sensory Characteristics of Dairy-Tigernut Yoghurt using Ginger as Bio-Preservative

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K E Y W O R D S

Ginger,
Plant milk,
Sensory,
Tiger-nut,
Yoghurt

A B S T R A C T

Tiger-nut milk is a good substitute for cow milk in yoghurt production because of its health benefit, accessibility and availability especially for people living in low-income countries, people living with lactose intolerance and vegetarian. Ginger extract (4%) was added as a bio preservative to improve the keeping quality of products obtained. Effect of ginger extract was studied on both tiger-nut yoghurt, cowmilk yoghurt and the blends. Microorganisms were identified during storage, total sugar and titratable acidity were evaluated and organoleptic properties were assessed. Microbial count was lower in samples with ginger extract and pathogenic microorganisms were not detected during storage. Microorganisms isolated were Lactobacillus delbrueckii, Streptococcus thermophilus, Lactobacillus plantarum, Pediococcus acidilactic, Saccharomyces cerevisiae, Leuconostoc mesenteroides, Bacillus subtilis, Staphylococcus epidermidis, Aspergillus niger and Micrococcus roseus. Tiger-nut generally increased the total sugar and pH of the samples and reduced the titratable acidity. These findings suggested that addition of ginger can increase the keeping quality of dairy, tiger-nut yoghurt and their blends without altering the organoleptic properties thereby providing healthy diet and reducing nutritional related disease.

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INTRODUCTION

Yoghurt is usually obtained from cow milk; though ewe, goat and buffalo also supply appreciable quantity of milk. Animal milk are expensive and not accessible to everyone so, there is need to explore alternative source of milk to meet the demand of the teaming population in order to improve their micronutrient intake, nutritional and health status. Lactose intolerance, religious believe and vegetarianism are other factors for exploring milk and milk product from plant source (Malomo and Abiose, 2019). Yoghurt is the most popular probiotic containing food because of its attractive appearance, texture, desirable taste and consumer's satisfaction (Ogundipe *et al.*, 2021). The probiotic microorganisms involved in fermentation of yoghurt have been reported to improve the health of the consumer by having positive effect on metabolic rate, absorption of nutrients, immune function, and maintaining intestinal microbial balance (Ogundipe *et al*., 2021). Milk and yoghurt analogue has been produced from soy milk, mung beans, coconut and tiger-nut (Onyimba, 2022).

Tiger-nut (*Cyperus esculentus*) is a tuber crop which is usually consumed raw or processed into products such as milk, meal and powder. It contains starch, oil rich in oleic acid, essential micronutrients (calcium, magnesium, iron and phosphorus), amino acids, vitamins E and C. It is used as additive in ice cream production, in composite flour for making biscuits, bread and other pastries and in production of beer and liquor (Bamishaye and Bamishaye, 2011; Jing *et al*., 2016; Ogo *et al*., 2018). Tiger-nut milk is popular in Spain and Nigeria where it is produced in household quantities, small scale and large scale. It is a light brown coloured non-alcoholic drink obtained from aqueous extract of tiger-nut tuber. It is consumed at home, during ceremonies, and sold in restaurants and supermarkets. The beverage is also gaining more attention around the world because of its nutritional benefit and organoleptic properties. Milk from tiger-nut is rich in starch, oleic acid, linoleic acid and arginine (Bamishaye and Bamishaye, 2011; Jonas *et al*., 2019). Milk obtained from tiger-nut into different milk products like pasteurized milk and condensed milk and it is suitable for people with cow milk allergies. The biological value of its protein content is high and it is higher than the recommended standard of FAO/WHO for adult (Ukwuru and Obodo, 2011).

ne of the challenges with tiger-nut milk is short shelf life because it cannot be heated above 72 °C during pasteurization to prevent jellification of starch (Jonas *et al*., 2019). Alertness on the use of safe additives by the consumers has increased the use of bio preservatives in foods. Spices such as ginger, garlic, *Xylopia aethiopica*, black pepper and cloves have been used to improve the organoleptic properties, microbiological characteristics and anti-oxidative activities of food. Ginger (*Zingiber officinale*) rhizome contain gingerol and shagoal which gives it desirable aroma and taste and also has therapeutic effect in the body (Malomo *et al*., 2020). Several authors have worked on the antibacterial, antifungal and antioxidant properties of ginger (Olaniran *et al*., 2018; Malomo and Abiose, 2020). Use of natural flavours could exert positive effect on the health of the consumer by serving as safe bio preserved functional food (Njoya *et al*., 2018). This research aims to study effects of ginger extract on the microbial population, types of microorganisms, safety and acceptability of dairy-tiger-nut yoghurt.

MATERIALS AND METHODS

Cow milk was obtained from Obafemi Awolowo University Teaching and Research farm, Ile – Ife, Nigeria. Tiger-nut and ginger were obtained from "Odoogbe" market, Ile – Ife. Media and chemical used for this research were of analytical grades.

Preparation of ginger

Ginger was washed, peeled, sliced and dried in hot air oven at 60 oC to 5 % moisture content and ground in a domestic blender. The powder obtained was sieved through 0.5 mm mesh and 100 g was soaked in 500 ml of distilled water. The mixture was stirred on magnetic stirrer and filtered with muslin cloth. The supernatant was dispensed into an airtight plastic and kept at 4 oC Modified method of Olaniran *et al*. (2019).

Production of tiger-nut milk

Method of Sanful (2009) was used for production of tiger-nut milk. Tiger-nut was cleaned, sorted, washed in portable water and soaked in water for 12 h. The water was drained, tiger-nut was rinsed in portable water and 450 g was ground in 1 L of water using a domestic blender. The mixture was double filtered through muslin cloth, residue was discarded and the milk was poured into a clean plastic container.

Production of dairy – tiger-nut yoghurt

Tiger-nut was mixed with cow milk at ratio 50:50, with or without addition of 4% ginger extract, 4% ginger extract was added to cow milk and 4% ginger extract was added to tiger-nut milk. The control samples are100% cow milk and 100% tiger-nut milk. These milk samples were pasteurized in water bath at 72 oC for 30 min, cooled to 43 oC, inoculated with 1.5% of starter culture and incubated in Gallen Kamp incubator for 10 h at 45 oC. Each sample was dispensed into sterile sampling bottle for analyses (modified method of Malomo and Abiose, 2020).

Table 1. Sample preparation

Code	Sample
DY	100 % cow milk yoghurt without ginger
TY	100% tiger-nut yoghurt without ginger
BY	50% tiger-nut, 50% cow milk yoghurt without ginger
DG	100% Cow milk yoghurt and + ginger
TG	100% tiger-nut yoghurt and + ginger
BG	50% tiger-nut, 50% cow milk yoghurt and + ginger

Microbiological analyses

Each sample (5 ml) was thoroughly mixed with peptone water (45 ml) in a stomacher and diluted appropriately. Appropriate dilution (1 ml) was pipetted in sterile plate and 20 ml of molten agar was poured. Total viable count (TVC) and lactic acid bacteria (LAB) were enumerated using Nutrient agar and MRS agar respectively. The petri dishes were incubated for 24 h at 35 °C for TVC and for 72 h at 35°C for LAB respectively. The colonies formed were counted and result was recorded in log colony forming unit per ml. Pure isolates were obtained by streaking colonies on appropriate agar and later streaked on agar slant in McCartney bottles and kept at 4 °C (Harrigan, 1998).

Appearance of colony on plates and morphological characteristics, Gram's staining and biochemical tests were used for the identification of isolate. Colony characteristics, shape of cell, size of cell, type of budding, assimilation of carbon and nitrate sources were used for identification of yeast isolate. Mould isolate was identified using the colour of spores, reproduction, type of hyphae and presence of special structures (Harrigan, 1998).

Determination of Total sugar content

Total sugar of yoghurt samples was determined using the anthrone reagent method described by Morris (1948). Glucose (0.01 g) was dissolved in distilled water (100 ml) to produce the stock solution for Standard sugar (0 - 1000µg). Yoghurt samples were diluted appropriately and double filtered through Watman 1 filter paper. The filtrate (1 ml) was pipetted into test tube containing 4 ml of anthrone reagent and boiled at 100 ^oC. The absorbance was read against reagent blank in spectrophotometer at 620 nm (Spectrumlab 752S, YM1206PHB2, China). Anthrone reagent (4 ml) was added to each sugar standard (1 ml) and the absorbance was obtained at 620 nm. The amount of sugar in each yoghurt samples was obtained from the standard glucose curve (Malomo *et al*., 2019).

Determination of Titratable acidity

Each sample (10 ml) was poured into conical flask and thoroughly mixed with distilled water (10 ml). Phenolphthalein indicator (3 drops) was added and was titrated against 0.1 N NaOH (AOAC, 2005).

Determination of pH

pH of the yoghurt samples was determined using pH meter (Philips model PHS-3C) which was calibrated using buffer 4 and 7. The electrode was inserted into each yoghurt sample and the readings displayed on screen was recorded (AOAC, 2005).

Sensory assessment

Freshly prepared yoghurt samples were coded and presented to fifteen panelists that were familiar with yoghurt. The samples were analyzed for colour, taste, flavour and overall acceptability using a 9 -point Hedonic (Montgomery, 2004).

Statistical analysis

The results were analyzed using SPSS (2010) for standard deviation and least significant difference. Principal Component Analysis, Agglomerative Hierarchical Clustering were analyzed using XLSTAT (2014).

RESULTS AND DISCUSSION

The frequency of the microorganisms is shown in Figure 1. *Lactobacillus delbrueckii* (25.3%), *Streptococcus thermophilus* (23.2%), *Lactobacillus plantarum* (12.4%), *Pediococcus acidilactic* (9.6%), *Saccharomyces cerevisiae* (12.6%), *Leuconostoc mesenteroides* (7.3%), *Bacillus subtilis* (4.9%), *Aspergillus niger* (1.2%), *Micrococcus roseus* (1.5 %) were isolated from the yoghurt samples during storage. *Lactobacillus delbrueckii, streptococcus thermophilus* and *Lactobacillus plantarum* were isolated from all samples from week 0 to week 4. *Leuconostoc mesenteroides* was isolated in all samples at week 0 and week 1. Malomo and Abiose (2020) also reported the viability of lactic acid bacteria in soy and dairy yoghurt. Lactic acid bacteria utilized the sugar present in yoghurt as carbon source and produce organic acids and volatile substances that improves the consistency and organoleptic properties of fermented food. They also reduce the pH and produce antimicrobial substances that inhibit pathogenic microorganisms (Malomo *et al*., 2020). *Pediococcus acidilactici* was isolated from TY, TG, BY and BG from week 0 – week 4 and *Saccharomyces cerevisiae* was isolated from week 1 to week 4. *Saccharomyces cerevisiae* was isolated from all yoghurt samples at the fourth week of storage. *Staphylococcus epidermidis* was isolated in TY at week 1 while *Micrococcus rubeus* and *Aspergillus niger* was isolated from TY at week 3 and week 4. All strains of *Pediococcus acidilactici* has ability to grow at 50°C but cannot withstand heating at 70 ^oC for 10 min (De Vos, 2009).

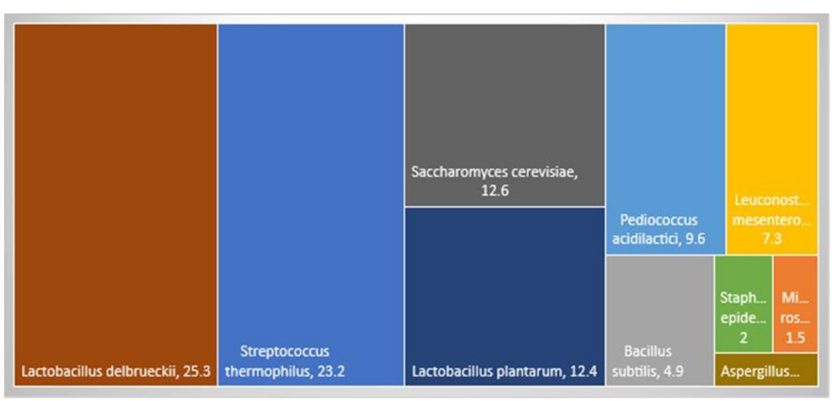

Figure 1. Percentage Occurrence of Microorganisms isolated from dairy - tiger-nut yoghurt during storage (%)

Total viable count of yoghurt

The TVC ranged between 3.85 to 9.38 log CFU/ml (Table 2). TY had the highest microbial count (8.20 log CFU/ml) at week 0 which was significantly different ($p < 0.05$) from the TVC of other samples. Addition of ginger significantly decreased the TVC of yoghurt samples produced from 100% tiger nut. At week 2, the TVC was highest in TY (9.38 log CFU/ml) followed by DY (8.410 log CFU/ml) and lowest in the BG (8.13 log CFU/ml). Addition of ginger significantly reduce ($p < 0.05$) the microbial count of all yoghurt samples from week 2 to week 4. The TVC of all yoghurt sample were within the acceptable range from week 1 to week 2. Samples DY, BY and DG containing cow milk still conform to the standard at week 4 (CODEX, 2011).

Table 2. Total viable count of dairy- tiger-nut yoghurt

	Storage Period				
Sample	**Week 0**	**Week 1**	**Week 2**	**Week 3**	**Week 4**
DY	7.33 ± 0.04^{a}	8.40 ± 0.57^{a}	8.41 ± 0.01^{b}	5.72 ± 0.11^{ab}	7.35 ± 0.35^{a}
TY	8.20 ± 0.57^{b}	8.44 ± 0.03^{a}	9.38 ± 0.10^{a}	5.89 ± 0.08^{a}	5.08 ± 0.07^{c}
BY	7.34 ± 0.57^{a}	8.10 ± 0.57^{a}	8.15 ± 0.57^{cd}	5.41 ± 0.10^{c}	6.81 ± 0.09^{b}
DG	7.32 ± 0.03^{a}	8.29 ± 0.10^{a}	8.31 ± 0.14^{bcd}	5.54 ± 0.04^{cd}	7.18 ± 0.84^{ab}
TG	7.19 ± 0.13^{a}	8.17 ± 0.07^{a}	8.34 ± 0.03^{bc}	5.54 ± 0.28^{cd}	4.94 ± 0.28^{c}
BG	7.30 ± 0.28^{a}	7.95 ± 0.57^{a}	8.13 ± 0.21^{d}	5.34 ± 0.13^{d}	3.95 ± 0.21^{d}

DY: Dairy Yoghurt, TY: Tiger-nut Yoghurt, BY: 50% Dairy + 50% Tiger-nut, Yoghurt, DG: Dairy Yoghurt + 4% Ginger Extract, TG: Tiger-nut Yoghurt + 4% Ginger Extract, BG: 50% Dairy + 50% Tiger-nut Yoghurt + 4% Ginger Extract. Values are means of three replicates ± standard error. Means followed by different superscript in the same row are significantly different at $p<0.05$

The lactic acid bacteria count of the dairy – tiger-nut yoghurt

The count generally increased during storage from week 0 to week 2 and decreased from week 2 to week 3 (Table 3). TY (4.77 – 5.41 log CFU/ml) generally had significantly lower count ($p < 0.05$) than DY (4.95 – 6.41 log CFU/ml) from week 1 to week 2 while counts were higher in TY (5.34 – 5.15 log CFU/ml) than DY (5.18 – 5.08 log CFU/ml) from week 3 to week 4 but the difference was not significant ($p > 0.05$). Ginger extract reduced LAB count in the samples but the reduction was not significant ($p > 0.05$) in DY and DG from week 0 to week 4 and also in BY and BG from week 0 to week 4. This show that ginger extract is a suitable bio preservative for production of functional yoghurt. Malomo *et al*. (2020) also reported that ginger did not affect the viability of LAB in cheese.

Table 3. Lactic acid bacteria count of dairy – tiger-nut yoghurt

	Storage Period				
Sample	Week 0	Week 1	Week 2	Week 3	Week 4
DY	4.95 ± 0.19^{a}	6.28 ± 0.06^{a}	6.41 ± 0.10^{a}	5.18 ± 0.13^{b}	5.08 ± 0.05^{b}
TY	4.77 ± 0.13^{a}	5.00 ± 0.42^{b}	5.41 ± 0.01^{b}	5.34 ± 0.06^{ab}	5.15 ± 0.06^{ab}
BY	4.07 ± 0.10^{b}	6.80 ± 0.20^{a}	5.35 ± 0.05^{b}	5.32 ± 0.03^{ab}	5.11 ± 0.16^{b}
DG	4.77 ± 0.17^{a}	5.95 ± 0.07^{a}	4.54 ± 0.06^{c}	5.28 ± 0.07^{ab}	5.26 ± 0.04^{ab}
TG	4.85 ± 0.07^{a}	5.85 ± 0.04^{a}	5.27 ± 0.04^{b}	4.69 ± 0.06^{c}	4.51 ± 0.21^{c}
BG	4.90 ± 0.14^{a}	6.08 ± 0.08^{a}	5.30 ± 0.42^{b}	5.41 ± 0.18^{a}	5.33 ± 0.06^{a}

DY: Dairy Yoghurt, TY: Tiger-nut Yoghurt, BY: 50% Dairy + 50% Tiger-nut, Yoghurt, DG: Dairy Yoghurt + 4% Ginger Extract, TG: Tiger-nut Yoghurt + 4% Ginger Extract, BG: 50% Dairy + 50% Tiger-nut Yoghurt + 4% Ginger Extract. Values are means of three replicates ± standard error. Means followed by different superscript in the same row are significantly different at $p<0.05$

The total sugar content of dairy – tiger-nut yoghurt

The total sugar content of dairy – tiger-nut yoghurt ranged between 99.509 – 152.002 mg glucose ml from week 0 to week 4 (Table 4); it generally decreased during storage and was higher in TY than DY. The range of total sugar obtained was slightly higher than 2.0 – 11% reported by Ukwuru *et al* (2008). Addition of tiger-nut significantly increased the total sugar content of the dairy yoghurt during storage. Yoghurt samples containing ginger extract generally had higher content of total sugar. Total sugar was generally higher in yoghurt samples containing tiger nut (136.248 – 152.002 mg glucose/ml) than cow milk (99.509 - 151.391 mg glucse/ml). Higher sugar content of yoghurt samples containing tiger-nut is probably due to high carbohydrate content of the nut (Sani *et al*., 2019). Tiger-nut milk is an emulsion of oil droplets in an aqueous phase containing starch granules and other solid particles (Rosello-Soto *et al*., 2018).

Table 4. Total sugar content of cow milk – tiger-nut yoghurt during storage (mg glucose/ml)

	Storage Period				
Sample	Week 0	Week 1	Week 2	Week 3	Week 4
DY	151.391±0.141^{bc}	143.890±0.003^{d}	131.059±0.013^{f}	133.794±0.048^{c}	99.509±0.041^{f}
TY	152.002±0.003^{a}	148.096±0.035^{a}	146.133±0.014^{c}	142.207±0.017^{a}	136.248±0.068^{c}
BY	151.462±0.080^{b}	146.344±0.062^{c}	150.550±0.007^{a}	139.612±0.047^{b}	135.126±0.037^{d}
DG	151.195±0.071^{c}	139.613±0.028^{e}	134.565±0.354^{e}	133.864±0.020^{c}	117.878±0.028^{e}
TG	151.882±0.116^{a}	147.676±0.014^{b}	148.798±0.043^{b}	142.768±0.014^{a}	139.262±0.028^{b}
BG	151.601±0.030^{b}	146.414±0.018^{c}	144.100±0.014^{d}	139.683±0.004^{b}	140.244±0.020^{a}

DY: Dairy Yoghurt, TY: Tiger-nut Yoghurt, BY: 50% Dairy + 50% Tiger-nut, Yoghurt, DG: Dairy Yoghurt + 4% Ginger Extract, TG: Tiger-nut Yoghurt + 4% Ginger Extract, BG: 50% Dairy + 50% Tiger-nut Yoghurt + 4% Ginger Extract. Values are means of three replicates ± standard error. Means followed by different superscript in the same row are significantly different at $p<0.05$

Titratable acidity of dairy – tiger-nut yoghurt

The titratable acidity (TTA) of yoghurt samples is shown in Fig. 3. The TTA of the freshly prepared yoghurt samples was between 0.59 and 1.40 %. It was generally lower in yoghurt samples produced from tiger-nut and the blends (0.57 – 0.83%) than dairy yoghurt (1.40 – 2.03%) throughout storage period. Ginger extract generally facilitate acid production in yoghurt samples. Low TTA was also reported with increase in addition of tiger-nut milk by Ojuko *et al*. (2019).

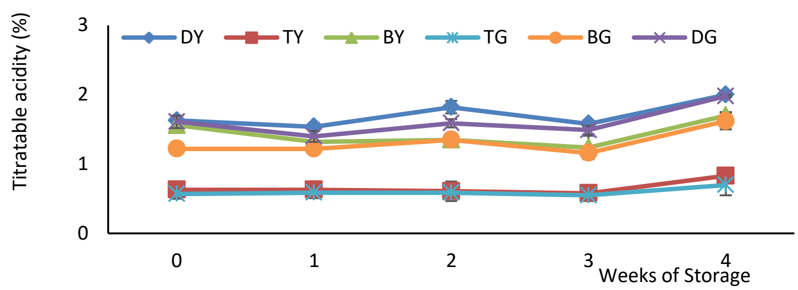

Figure 3. The titratable acidity of dairy – tiger-nut yoghurt during storage

DY: Dairy Yoghurt, TY: Tiger-nut Yoghurt, BY: 50% Dairy + 50% Tiger-nut, Yoghurt, DG: Dairy Yoghurt + 4% Ginger Extract, TG: Tiger-nut Yoghurt + 4% Ginger Extract, BG: 50% Dairy + 50% Tiger-nut Yoghurt + 4% Ginger Extract.

pH of dairy – tiger-nut yoghurt

The pH of yoghurt samples generally decreased with increase in storage time (Figure 4). It was highest in TY (5.76 – 6.00) which contain 100% tiger-nut throughout the period of storage while DY containing 100% cow milk (4.22 – 4.63) had the lowest. Addition of 4% ginger extract reduced the pH of both tiger-nut and cow milk yoghurt and their blends. The reduction in pH also led to reduction in both total viable count and lactic acid bacteria count of these samples. This also shows that ginger extract is a potential bio preservative in both plant and animal milk. The reduction in pH could be due to the activities of the microorganisms involved in the fermentation process. Since the samples were not pasteurized after production, the microorganisms continued utilizing the available carbon thereby converting it to simple sugars that were ultimately utilized as by microorganisms as source of nutrient. (Adepoju *et al*., 2012; Malomo et a., 2020). These microorganisms also produced organic acids such as lactic acid, acetic acid and butyric acid which also eliminates the growth of pathogenic microorganisms that can cause health challenges thereby establishing the safety of the food. Organic acid has been reported to have bacteriocidal and bacteriostatic effect on both spoilage and pathogenic microorganisms that might have adverse effect on the quality and safety of food (Adepoju *et al*., 2016).

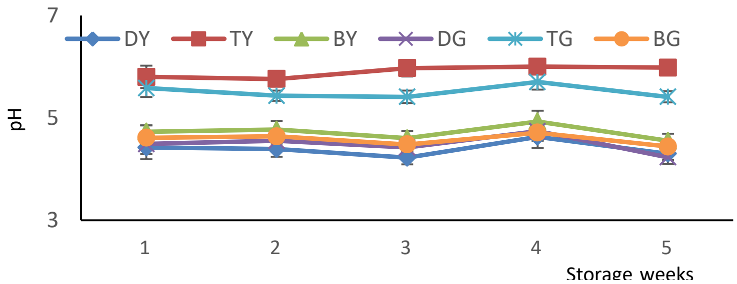

Figure 3. The titratable acidity of dairy – tiger-nut yoghurt during storage

DY: Dairy Yoghurt, TY: Tiger-nut Yoghurt, BY: 50% Dairy + 50% Tiger-nut, Yoghurt, DG: Dairy Yoghurt + 4% Ginger Extract, TG: Tiger-nut Yoghurt + 4% Ginger Extract, BG: 50% Dairy + 50% Tiger-nut Yoghurt + 4% Ginger Extract.

Sensory evaluation of dairy – tiger-nut yoghurt samples

Table 5 shows the results of the sensory properties of dairy-tiger-nut yoghurt. DY was scored highest for colour, taste, flavour and overall acceptability followed by DG. Scores obtained for DG and DY was not significant except for the taste which had significantly lower score ($p < 0.05$) in DG showing that 4% ginger extract had significant effect on the taste of dairy yoghurt. Addition of 4% ginger extract also significantly increased the texture of all yoghurt samples. The low score for yoghurt produced from tiger-nut may be due to the fact that the panelists are more familiar with dairy yoghurt than tiger-nut yoghurt. The yoghurt blends BY and BG had significantly higher score for taste, flavour and colour and overall acceptability than TG and TY. Njoya *et al*. (2018) also attributed decrease in the overall acceptability of yoghurt to increase in the concentration of ginger. Thus, yoghurt with high acceptability can be obtained from blends of dairy and tiger-nut milk with or without ginger extract to reduce cost of production, increase accessibility of yoghurt and improve the nutritional status of populace.

Table 5. Sensory evaluation of yoghurt samples

Samples	Colour	Texture	Flavour	Taste	Overall acceptability
DY	8.60±1.06^{a}	5.00 ±1.62^{d}	8.10 ±1.02^{a}	8.10±0.99^{a}	8.60±1.06^{a}
TY	4.30±1.32^{c}	4.30 ±1.83^{d}	4.40 ±1.41^{c}	4.30 ±1.61^{cd}	4.30±1.32^{c}
BY	5.40±1.34^{b}	4.40 ±1.23^{d}	5.20 ±1.23^{ab}	5.60±1.17^{ab}	5.40±1.34^{b}
DG	8.30±0.91^{a}	5.80±1.27^{c}	7.40 ±2.30^{a}	6.70±1.05^{b}	8.30±0.91^{a}
TG	4.00±1.77^{c}	7.10±1.26^{a}	4.40 ±1.18^{c}	4.20±1.04^{d}	4.00±1.77^{c}
BG	5.00±1.06^{b}	6.80 ±1.62^{b}	6.00 ±1.02^{b}	5.40±0.99^{ab}	5.70±1.06^{b}

DY: Dairy Yoghurt, TY: Tiger-nut Yoghurt, BY: 50% Cow milk + 50% Tiger-nut Yoghurt, DG: Dairy Yoghurt + 4% Ginger Extract, TG: Tiger-nut Yoghurt + 4% Ginger Extract, BG: 50% Cow milk + 50% Tiger-nut Yoghurt + 4% Ginger Extract. Values are means of three replicates ± standard error. Means followed by different superscript in the same row are significantly different at $p<0.05$

CONCLUSION

Ginger extract (4%) increased the shelf life of the yoghurt products for four weeks. All samples with ginger extract remain stable and retained the fresh aroma while samples without ginger extract showed changes in aroma, viscosity and appearance after week 2. Thus, safe yoghurt with extended shelflife can be processed from dairy, tiger-nut milk and their blends. It is recommended that people should be sensitized on the importance of plant milk to enhance good nutrition and healthy living. Awareness should also be raised on importance to tiger-nut yoghurt in the developing countries to increase its acceptability.

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Effect of Variety on Growth and Forage Yield of Orange Fleshed Sweet Potato (OFSP) on Tropical Humid Soil: Implication for Animal and Human Nutrition.

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K E Y W O R D S

Nutrition
OFSP,
UMUSPO 3,
UMUSPO 4,

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A B S T R A C T

The study was conducted to determine the effect of OFSP variety on growth and forage yield in humid soil: Implication for animal and human nutrition. The experiment was carried out in The Teaching and Research Farm, Federal College of Education (Technical) Omoku during the first farming season. The design adopted for the study was randomized complete block design (RCBD) with two (2) treatments (solo gold and mother's delight) each replicated three (3) times and lasted ninety (90) days. The length of planting materials was thirty centmetres (30cm), planted at a distance of 10m by 75 cm, weeding was done once and data were collected on the following sprouting, number of leaf and branches, vine length, fresh tuber yield and fresh forage yield. The data were summarized and subjected to mean, percentage and t-test .It was observed that the breeding lines had more 50% (solo gold, 56% and mother's delight,60% sprouting from the first seven (7) days after planting (DAP) and continued to above 80% at 21DAP (solo gold, 84.67% and mother's delight, 85.2%). The growth parameters mean number of leaves, number of branches and vine length showed numerical difference between varieties. The fresh tuber and forage yields were significantly different at 0.5 % probability. It was concluded OFSP varieties have unique characteristics the meet human nutrition demands. Solo gold (UMUSPO 4) had low fresh tuber yield but high forage yield and vegetative growth. Mother's delight (UMUSPO 3) had high fresh tuber yield but low fresh forage. OFSP is recommended for farmers in Omoku depending on the products needed, solo gold breeding line should be cultivated for leafy vegetable and mother's delight for tuber.

INTRODUCTION

Nutrition and health are greatly related, good nutrition is a forerunner of healthiness and wellbeing. In recessed economy witness in Nigeria and other parts of the world in last ten years quality nutrition for both human and animals has been a subject in many health discourses. In feeding, qualitative nutrition is been replaced by quantitative nutrition leading to various deficiencies and mal – nutrition. Today, there are numerous ill- health conditions which could have been remedied through good nutrition.

To bridge the cap, between nutrition and health of farm animals and human, researchers have developed bio-fortified crop varieties from existing ones so that their consumption by man and farm animals boost their growth and wellbeing. Bio-fortification is biotech strategy enhances the nutritional / food value of staple food crops by increasing the density of vitamins and minerals in the crops through either conventional plan breeding or genetic engineering. Bio- fortified staples play a serious role in food security through high yielding, early maturing, general improvement in quantity and quality, wider distribution in different agro-ecological areas and other specific characteristics. Some of the staples with bio-fortified lines are bêta- cassava, yellow maize, cowpea and sweet potato.

Sweet potato (*Ipomoea batatas* L.) is well known tuber crop in the Sub Saharan Africa (Low *et al*., 2009) and one of the most important versatile food crops. Sweet potato has nutritional advantage for the rural and urban dwellers (Ingabire and Hilda, 2011) and grows in kind of marginal soils, wide adaptation with high yielding and high resistance to drought (Lu *et al*., 2006). There are many varieties of sweet potato grown in more than 115 countries over the world (Aina *et al.,* 2012; Aywa *et al*, 2013; FAOSTAT, 2019) The bio-fortified sweet potato line is called orange fleshed sweet potato (OFSP) and was developed by Centre for International Potato Centre (CIP) and distributed by Agricultural Research Council of Nigeria (ARCN). OFSP variety of sweet potato was developed through conventional breeding in 1995 and is gaining popularity in different agro-ecological zones due to its cultivars characteristics. National Root Research Institute, Umudike has developed many genotype breeding lines of OFSP (Kanu, Afuape, Ezeocha, and Nwafor (2018). King J (UMUSPO1) was released in December, 2012 while mother's Delight (UMUSPO3) was released in June 2013.

Hernández Suárez *et al*. (2016) reported that SP also provides the substantial quantities of selected vitamins (Vitamin C and Pro-vitamin A ,PVA), specific minerals (potassium, magnesium, and calcium), and various bioactive compounds (phenolic acids and anthocyanins [ACN]) for consumers. Van Jaarsveld *et al*., (2006) reported that purple- and orange-fleshed cultivars possess higher quantities of phenolic acids and anthocyanins (CAN) and carotenes in comparison with white-fleshed cultivars. OFSP possesses the characteristic of attractive sweet taste and eye-pleasing yellow to orange color to children in comparison with potato varieties (Kaguongo, 2012) and a good source of non- digestible dietary fiber, specific minerals, different vitamins, and antioxidants (Endrias, Negussie, and Gulelat, 2016; Rodrigues, Barbosa, and Barbosa, 2016). The OFSP varieties have additional advantages like early maturing (3- 4 months), resistance to weevils attack and sweet potato viral disease and can be easily processed into valued chain products. Tuber may be processed into different kinds of valued chain products including flour, chips, crisp, puree and juice. It serves as a cover crop, suppressing weed growth; leaves are consumed when green by humans and livestock. The leaves may be processed into hay, silage and products for feeding farm animals. Dr Kirimi Sindi, the county manager International Potato Centre (CIP), says pregnant, lactating women and children under five (especially children under two) are the most affected by malnutrition in general. The reason for this is the high nutrients needed at these stages, but when consumed, the potato can correct that. He notes that only 125 grams of orange-fleshed sweet potato (OFSP) can supply the recommended daily allowance of vitamin A for children and lactating women and also a family of five could generate an adequate annual supply of vitamin A from a 500 square metre plot (The news Times, 2018, January 28).

The significance of OFSP in fighting mal-nutrition and ill- health in human particularly among children and women of reproductive age in Nigeria and other third world countries is not debatable. It improves digestion, gain weight, immune system and prevent vitamin A deficiency. It is antidote for stomach ulcer, diabetes, dehydration, arthritis, bronchitis and inflammation (Mitra 2012). It is a crop for food security and can stop and fight hunger. This crop has not registered its presence in many agro-ecological zones of the country hence undermining its production and utilization. The main cultivars in Nigeria identified by common(local) names and scientific codes are *king J'* (UMUSPO1), *Mother's delight* (UMUSPO3) and Solo gold (UMUSPO4) but which of these varieties is adaptable to Omoku agro-ecological zone in terms of growth and forage yield to meet human and animal nutrition. This experiment was carried out to answer the question of which variety of OFSP that should be cultivated in Omoku agro-ecological zone. As King J (UMUSPO1) is more popular *Mother's delight* (UMUSPO3) and Solo gold (UMUSPO4) were used for the study.

MATERIALS AND METHODS

The experiment was carried out at Teaching and Research Farm of Department of Agricultural Education Federal College of Education (Technical), Omoku Rivers State.

The study was experimental design adopted was randomized complete block design (RCBD) with two treatments each replicated three (3) times and experiment lasted 90 days. The treatments were UMUSPO1 *(king J*) and UMUSPO 3 (*Mother delight*) vines as planting materials. The experiment area for experiment measured 30 by 10m and experimental area was divided into 6 experimental plots each measuring 5 by 10 m and each plot has 8 beds measuring 4 by 1m.

OFSP varieties- King j and mother delight vines were obtained from National Root Crop Institute, Umudike. The length of planting vines was 30cm and planted at distance of 75cm by 100cm on raised beds on second week of May 2022. Weeding was done once and supplying was also done 15 days after planting (DAP).

Measurement were collected on the following parameters

i Rate of sprouting by counting sprouting against non- sprouting at 7, 14 and 21 days after planting (DAP). Rate of sprouting = ${}^{number\ sprouting}/_{number\ planted}$ X 100

ii Number of leaves by counting at 7, 14 and 21 days after planting (DAP)
iii. Vine length measured 7, 14 and 21 days after planting (DAP)
iv. Number of branches at 7, 14 and 21 days after planting (DAP)
v. The fresh tuber yield was determined immediately after harvesting using measuring scale.
vi. The fresh forage yield was done by proper assembling of the vegetative parts and weighing using measuring scale.

All data collected was subjected percentage, mean, t- test analysis at 0.5 % probability

RESULT AND DISCUSSION

The rate of sprouting of different OFSP varieties is presented on Table 1. The result indicated 56 and 60% respectively for solo gold and mother delight at 7 days after planting (DAP). At 14 DAP the rate of sprouting are 71.2% and 72% for solo gold and mother delight respectively and also at 21 DAP, the rate of sprouting are 85.2% and 84.67% for solo gold and mother's delight, It could be deduced that two varieties (breeding lines) have higher capacity to sprout irrespective of the agro-ecological conditions but there was numerical difference between varieties and progressive increase in sprouting rate from 7 days to 21days. It could also be inferred that the planting vines (30cm) had sufficient number of nodes to effect positive sprouting and the vines handing strategy contributed to rate of sprouting of OFSP.

Table 1 Effect of variety of sprouting rate of OFSP in humid soil

Day After Planting/Varieties	Solo gold Mean	%	Mother's delight Mean	%
7DAP	24.00	56	22.40	60
14 DAP	28.8	71.2	28.48	72
21 DAP	*33.87*	*84.67*	*34.08*	*85.2*

Field report 2022

The observed results are similar to the observation reported by Puran and Ronell (2014) reported that vine cutting with 3 to 5 nodes achieve better germination and survival. The assumption is that large cutting has a higher opportunity for sprouting and development due to the presence of more nodes and higher carbohydrate reserve.

Table 2 Effect of Variety on Some Growth Parameters of OFSP

Days After Planting/Varieties	Solo Gold			Mother's Delight		
	Mean no. of leaves	Mean no.of branches	Mean vine length (cm)	Mean no.of leaves	Mean no.of branches	Mean vine length(cm)
7DAP	3.4	-	7.20	2.86	-	2.25
14DAP	7.5	1	16.30	6.4	-	13.23
21 DAPS	15.21	3	28.85	12.82	1	25.45

Field report 2022

Table 2 shows the growth parameters of different varieties of OFSP; mean number of leaves are 3.4,7.5 and 15.21 at 7,14 and 21 days after planting for solo gold whereas 2.86,6.4and 12.82 at the same period for mother's delight respectively . Solo gold had more leaves than mother's delight but the generally increased in number from 7 to 21 days after planting. The number of branches is 0, 1 and 3 at 7, 14and 21 days after planting for solo gold, also 0, 0 and 1 for mother 's delight during the same period respectively. The mean vine lengths are 7.20, 16.30 and 28.85cm for solo gold at 7, 14 and 21 days after planting whereas 2.25 , 13.23 and 25.45cm for mother's delight at 7,14 and 21 days after planting. It may be deduced that solo gold displays numerical increment in all the growth parameters measured. The observed may not only attributes of agro-ecosystem but genes related factors because two breeding lines differ in their genotype. The results are in agreement with Kapinga *et al*. (2010) and Egbe *et al*.(2012) reported variation in vine length and attributed it to differences in genetic make-up of the sweet potato varieties.

Table 3 t-test analysis of fresh tuber yield of different varieties of OFSP in humid soil

Varieties	Mean	S.D	N	df	S.E	t_{cal}	t_{tab}	Decision rule
Solo gold	3.08	1.61	3	5	1.15	6.23	2.57	significant
Mother's delight	10.28	3.76	3					

S.D means Standard deviation, N means total number, t_{cal} means t-calculated, t_{tab} means t-table value, S.E means standard error, df means degree of freedom.

Information on Table 3 shows the summarized *t*- test fresh yield of solo gold and mothers delight varieties of OFSP. The calculated t value 6.23 is greater than the table value 2.57. In conclusion, there is significant difference between the fresh yield weight of solo gold and mother's delight. The observed result may be due to the different genetic makeup of the two breeding lines. The differences in means show that mother's delight does in Omoku soil. The result is in tandem with the report by Pakkies *et al*.(2019) that there always variation in yield among varieties of the crop due to the translocation of manufactured food to storage or the path way of photosynthetic activities.

Table 4 t-test analysis of fresh forage yield of different varieties of OFSP in humid soil

Varieties	Mean	S.D	N	df	S.E	t_{cal}	t_{tab}	Decision rule
Solo gold	600	100	3	5	51.81	8.164	2.57	significant
Mother's delight	117	112.93	3					

S.D means Standard deviation, N means total number, t_{cal} means t-calculated, t_{tab} means t-table value, S.E means standard error, df means degree of freedom.

Information on Table 3 shows the summarized *t*- test fresh yield of solo gold and mothers delight varieties of OFSP. The calculated t value 8.164 is greater than the table value 2.57. In conclusion, there is significant difference between the fresh yield weight of solo gold and mother's delight. The observed result may be due to the different genetic makeup of the two breeding lines. The differences in means forage yield show that solo gold produces more forage than mother's delight and should be cultivated for feeding in Omoku.

CONCLUSION

OFSP varieties have unique characteristics the meet human nutrition demands. Solo gold (UMUSPO 4) had low fresh tuber yield but high forage yield and vegetative growth. Mother's delight (UMUSPO 3) had high fresh tuber yield but low fresh forage. OFSP is recommended for farmers in Omoku depending on the products needed, solo gold breeding line should be cultivated for leafy vegetable and mother's delight for tuber. The vine length for planting should be about 30cm or more to enhance sprouting and root development.

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Proximate and Mineral Properties of Smoothie Fortified with African Bread Fruit and Cashew Nut

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ABSTRACT

This study assessed the proximate and mineral properties of different samples of smoothie processed with African bread fruit and cashew nut. The smoothie was produced from five different fruits, (Apple, Beetroot, Banana, Pineapple and Soursop) then fortified with African bread fruit and cashew nut. The fruits were sorted, washed, diced and blended together. The concentration of African bread fruits and cashew nut differs in each smoothie samples. The seven smoothie samples were examined for their proximate and mineral properties. The result for proximate analysis showed that ash content ranged from 1.80-2.90 %, moisture 35.00-50.00 %, fat 3.00-4.50%, fiber 0.75-1.35%, protein 23.10-33.75 % and carbohydrates 18.60-35.35 %. The mineral properties reveled that sodium content ranged from 108-120mg/100g, potassium 400.0-680.0mg/100g, zinc 1.60-3.00mg/100g, and calcium ranged from 12-27mg/100g respectively. The fortification of smoothie with African bread fruit and cashew nut increased the level of carbohydrates, protein, crude fibre and mineral.

INTRODUCTION

Smoothies are thick beverage product prepared from raw fruit pulps and the blends (Danielle *et al.*, 2018). Smoothies may include other ingredients such as vegetables, water, crushed ice, fruit juice, sweeteners (such as honey, sugar, syrup), dairy products (such as milk, yoghurt, low fat or cottage cheese, whey powder), plant milk (such as coconut milk, tiger nut milk, almond nut milk, soy milk), seeds (such as celery seeds), spices (such as ginger, garlic), tea, chocolate, herbal supplements or nutritional supplements (Zavasta, 2009; Teleszko and Wojdyto, 2014). Smoothies contain dietary fiber from the fruit pulp and hence, thicker than fruit juices, with its viscosity resembling that of milkshake (Anon, 2023). Smoothies can be sub-divided into three main categories viz. fruit only, Fruit and dairy product and functional smoothie (Srivasta *et al*, 2019). Fresh smoothies refreshes the body system by promoting balanced diet and improving the immune system (Victor-Aduloju *et al*., 2020). Many of the vitamins and minerals are found in fruits and vegetables are strong antioxidants (Barba *et al*., 2012). The important roles of fruits and vegetable in preventing chronic diseases such as cancer, stroke, heart disease, alzhemier have been reported (Andres *et al*., 2016). African breadfruit (*Treculia africana*) is a grain legume which is currently being considered as several sources of nutrient (Okonkwo and Ubani, 2007). It contributes immensely to the diet of Nigerians (Iwe and Ngoddy, 2001). Umezuruike *et al*., (2016) reported important contents of Alanine, Isoleucine, lysine, histidine, aseptic acid, glutamic acid, glycine, proline, threonine, tyrosine, phenylannine, methionine and valine in African bread fruit. In Igbo it is called “Ukwa” which is the most popular tribal name. Other local names include “afon” by Yorubas, “ize” by Benin, “Ediang” by Efik, Ibibios and Annangs and “barafutu” in Hausa. It is a rich source of minerals such as potassium, calcium, sodium, copper, iron, magnesium and vitamins (Osabor *et al*., 2009; Derbyshire, 2017). African bread fruit seed is a proficient alternative to animal protein in human diets and non-ruminant animal husbandry (Akande and Fabiyi, 2010). The defatted seed contains 19% protein, which is higher than that of cereals and similar to most pulses; and is particularly, high in aromatic amino acids, which makes it a potential source of good quality protein. The raw seed contains 40 to 50% carbohydrate as well as, minerals and vitamins (Oyetayo and Omenwa, 2006).

Cashew nut (*Anacarduim occidentale* L.) are excellent sources of nutrition. It is rich in unsaturated fatty acids, palmitoleic, vaccenic, linolenic, and gadoleic acids, and especially oleic and linoleic acids (Ogunwolu *et al*., 2015). The nuts are also a good source of protein, carbohydrates, and dietary fiber (Soares *et al.,* 2013). The cashew nuts are majorly sold as export crop and few of kernels have beneficial effects on health, particularly on chronic diseases such as hypertension and obesity, coronary heart disease and diabetes (Tapsell, 2010).

The consumption of fruits and vegetables is getting pronounced in Nigeria. The desire to go for fresh fruit and vegetable that is healthy and nutritious than soda drinks that is high in caffeine and sugar by consumer is of high increase. Nigeria has many different fruits and nuts as a source of vitamins and minerals but due to lack of processing and good storage facilities, the fruits are been wasted and sometimes abandoned for insects to invade it and later rotten away. Smoothie have been mostly encouraged as beverage option for healthy life. The addition of African bread fruit and cashew nut into smoothie is well known but has not widely studied. Therefore this study aimed at the determination of proximate and mineral properties of smoothie fortified with African bread fruit and cashew nut.

MATERIALS AND METHODS

Source of Materials

The *Treculia africana* (African bread fruit) was purchased at Eke-awka market, Anambra state while, *Beta vulgaris* (Beetroot), *Ananas comosus* (Pineapple), *Musa* spp. (Banana), *Anona muricata* L.(Soursop) were purchased at Nkwo Amaenyi and *Malus domestica* (Apple) and *Anarcadium occidentale* (Cashew nut) were purchased from Roban stores Awka, Awka South Local Government Anambra State.

Production of smoothie

All the fruits were washed thoroughly using good potable water. The bananas were peeled by using hand, the apples were cut open and seeds removed, pineapple were peeled with a clean knife and they were sliced and diced. The beetroots were peeled and diced and the soursop was cut open, seeds removed and then diced before blending. The fruits were blended with the African bread fruit and cashew nuts at different ratios with the aid of a smoothie blender (Binatone blender-grinder and smoothie maker BLG-585B- Black) which was switched on for 6 minutes to homogenized the samples and form a smoothie which was dispensed into sterile container. The samples were kept in the refrigerator at 20^0C.

Proximate Analysis

Crude fibre, protein, moisture, ash and crude content of the samples were determined according to standard methods of AOAC, (2015). Carbohydrates were determined by estimation using the following formula:

Carbohydrates (%) = 100- (Moisture + Protein + Fats + Crude fibre + Ash).

Mineral Determination

The mineral analysis was determined by the method described by AOAC, (2015). The samples were ashed (Lenton muffle furnace AF11/6) at 550°C. The ash obtained was boiled with 10 mL of 20% hydrochloric acid in a beaker and filtered into a 100 mL standard flask. The filtrate was made up to the mark with de-ionized water. The minerals sodium, (Na) and potassium (K) were determined from the solution using the standard flame emission photometer. NaCl and KCl were used as the standards (AOAC, 2015). Phosphorus (P) was determined calorimetrically using the spectronic 20 (Gallenkamp, UK; Kirk and Sawyer , 1991) with KH_2PO_4 as the standard. Calcium (Ca) and Zinc (Z) were determined using an atomic absorption spectrophotometer (AAS, Model SP9, Pye Unicam Ltd, Cambridge, UK). All values were expressed in mg/100 g.

Statistical Analysis

The data obtained were analyzed according to a completely randomized design with three replicates. Data were subjected to one way analysis of variance and the difference between means were evaluated by Duncan's multiple range tests using SPSS statistical program version 23.0. Significant difference was expressed at $p<0.05$.

RESULTS AND DISCUSSION

The effect of African bread fruit and Cashew nut addition on the proximate content of smoothie produced from the blends of Apple, Banana, Beetroot, Pineapple and Soursop is shown in Table 1. Crude fiber content of the samples ranged from 0.75-1.35%. The sample 7 had highest crude fiber content (1.35± 0.26%) and sample 6 had the lowest (0.75%). Samples 5 and Samples 6 are not significantly different ($p>0.05$) while sample 3, sample 4 and sample 7 are significantly different ($p<0.05$). This sample being high in fibre could be due to an increase in the African bread fruit. The values were within the range of research findings of Brijesh *et al*, (2021).

Crude protein content of the samples ranged from 22.70-33.75%. There were significant ($p<0.05$) differences in the crude protein content within the samples. Sample 7 had the highest value of 33.75 ±0.03%. The differences in the protein contents among the samples could be due to biochemical characteristics of the different types of fruits and nuts used. Addition of African bread fruits and cashew nut which has been reported to be high in crude protein content (Armstrong *et al.,* 2012). The protein content obtained in this study is also significantly higher than previously reported protein contents for fruit juices/ beverages (Dima *et al*., 2015). Moisture content of all samples ranged from 35.00-50.00 % but that of sample1, sample 2, sample 3 and sample 6 differed significantly ($p<0.05$) from other samples. However, no significant ($p>0.05$) difference existed between the moisture contents of sample 4, sample 5 and sample 7. Sample 6 had the least moisture content. The control which is sample 1 had the highest moisture content (50.00±2.65%) probably due to the absence of nuts and African bread fruit.

The Ash content of the smoothie sample ranged from 1.80- 2.90%%, with all the samples having no significant difference ($p>0.05$). Sample 1, has the highest ash content of 2.90% and sample 7 has the least ash content of 1.80%. The percentage of fat content of the smoothie ranged from 4.50-3.00% with the sample 7 (Apple, Banana, Beetroot, Pineapple and Soursop with 7:3% African bread fruit and Cashew nuts) having the least value of 3.00±0.26% and sample 1 having the highest value of 4.50± 0.26%. Fat is important in food because it promotes fat soluble vitamin absorption. (Borges *et al*., 1994). There is a significant difference ($p<0.05$) among all the samples of the smoothie.

The total carbohydrate of sample 1, sample 3, sample 4, sample 5, sample 6, has significant value ($p<0.05$) while sample 2 and sample 7 has no significant difference. The smoothie without African bread fruit and cashew nut had the lowest carbohydrate content. The presence of carbohydrates in the body builds up macromolecules, carbohydrate breaks down fatty acids and prevent ketosis which will form adipose tissues in the food (Ayrkoyed and Doughty, 1964). The results shows that carbohydrate contents significantly increased ($p<0.05$) with the addition of African bread fruit and Cashew nuts.

Table 1: Proximate analysis of smoothie samples (%)

Sample	Fibre	Protein	Moisture	Ash	Fat	Carbohydrate
S1	1.30^{ab}±0.26	22.70^{g}±0.03	50.00^{a}±2.65	2.90^{a}±0.10	4.50^{a}±0.26	18.60^{f}±1.00
S2	1.20^{ab}±0.26	22.90^{f}±0.03	48.00^{ab}±2.65	2.70^{b}±0.10	4.30^{ab}±0.26	20.90^{e}±1.00
S3	1.10^{abc}±0.26	22.95^{e}±0.03	44.00^{bc}±2.65	2.40^{c}±0.10	4.00^{bc}±0.26	25.55^{d}±1.00
S4	0.97^{bc}±0.26	23.10^{d}±0.03	42.00^{c}±2.65	2.30^{c}±0.10	3.80^{cd}±0.26	27.90^{c}±1.00
S5	0.78^{c}±0.26	23.30^{c}±0.03	40.33^{c}±2.31	2.10^{d}±0.10	3.50^{de}±0.26	30.32^{b}±1.00
S6	0.75^{c}±0.26	23.70^{b}±0.03	35.00^{d}±2.65	1.90^{e}±0.01	3.30^{ef}±0.26	35.35^{a}±1.00
S7	1.35^{a}±0.26	33.75^{a}±0.03	40.00^{c}±2.65	1.80^{e}±0.01	3.00^{f}±0.26	21.10^{e}±1.00

Values are means ± standard deviation of three (3) replicates. Data in the same column bearing different superscript differed significantly ($p<0.05$).

Keywords:S1= Apple, Banana, Beetroot, Pineapple and Soursop,S2= Apple, Banana, Beetroot, Pineapple and Soursop with 5:7% African bread fruit and Cashew nuts, S3= Apple, Banana, Beetroot, Pineapple and Soursop with 6:2% African bread fruit and Cashew nuts, S4= Apple, Banana, Beetroot, Pineapple and Soursop with 6:5% African bread fruit and Cashew nuts, S5= Apple, Banana, Beetroot, Pineapple and Soursop with 7:4% African bread fruit and Cashew nuts, S6= Apple, Banana, Beetroot, Pineapple and Soursop with 7:5% African bread fruit and Cashew nuts, S7= Apple, Banana, Beetroot, Pineapple and Soursop with 7:3% African bread fruit and Cashew nuts.

The effect of African bread fruit and Cashew nut addition on the mineral content of smoothie produced from the blends of Apple, pineapple, banana, beetroot and soursop are presented in Table 2. The mineral content ranged from 108-120 for sodium, 400-680 for potassium and 1.60-3.0 for zinc and calcium 12- 27 respectively. There was no significant difference ($p>0.05$) in the sodium content of all the samples except sample 6 and 7. The fruits with 7:3% African bread fruit and cashew nuts had the lowest sodium value of 108.00±2.65mg/100g. The control had the highest potassium value of 680.00±2.65mg/100g while sample 7 had the lowest potassium value. Smoothie with 7:3% African bread fruit and cashew nut had highest zinc content and it is significantly different ($p<0.05$) from all other samples. The zinc content of sample 1 to sample sample 5 are not significantly different. Sample 2 which was smoothie with 5:7 African bread fruit and cashew nut had the lowest amount of calcium (15.00±1.00mg/100g). The highest calcium contents were recorded in sample 7. The values of sodium, potassium, zinc and calcium were in accordance with those values reported by Andres *et al*., (2014) and Wall, (2006). Potassium happened to be the most abundant mineral followed by sodium then calcium and zinc respectively. Potassium is an essential nutrient that has a role in the synthesis of amino acids

Table 2: Mineral analysis of the smoothie samples (mg/100g)

Samples	Sodium	Potassium	Zinc	Calcium
S1	120.00^{a}±2.65	680.00^{a}±2.65	1.90^{bc}±0.26	12.00^{g}±1.00
S2	118.00^{a}±2.65	670.00^{b}±2.65	1.70^{bc}±0.26	15.00^{f}±1.00
S3	115.00^{ab}±2.65	660.00^{c}±2.65	1.60^{c}±0.26	18.00^{e}±1.00
S4	118.00^{a}±2.65	560.00^{d}±2.65	1.90^{bc}±0.26	20.00^{d}±1.00
S5	117.00^{a}±2.65	549.00^{e}±2.65	2.00^{bc}±0.26	22.00^{c}±1.00
S6	112.00^{bc}±2.65	540.00^{f}±2.65	2.20^{b}±0.26	25.00^{b}±1.00
S7	108.00^{c}±2.65	400.00^{g}±2.65	3.00^{a}±0.26	27.00^{a}±1.00

Values are means ± standard deviation of three (3) replicates. Data in the same column bearing different superscript differed significantly ($p<0.05$).

Keywords:S1= Apple, Banana, Beetroot, Pineapple and Soursop,S2= Apple, Banana, Beetroot, Pineapple and Soursop with 5:7% African bread fruit and Cashew nuts, S3= Apple, Banana, Beetroot, Pineapple and Soursop with 6:2% African bread fruit and Cashew nuts, S4= Apple, Banana, Beetroot, Pineapple and Soursop with 6:5% African bread fruit and Cashew nuts, S5= Apple, Banana, Beetroot, Pineapple and Soursop with 7:4% African bread fruit and Cashew nuts, S6= Apple, Banana, Beetroot, Pineapple and Soursop with 7:5% African bread fruit and Cashew nuts, S7= Apple, Banana, Beetroot, Pineapple and Soursop with 7:3% African bread fruit and Cashew nuts.

CONCLUSION

This result established the fact that smoothie produced from apple, banana, beetroot, pineapple and soursop fortified with African bread fruits and cashew nut had the higher values compared to the unfortified sample. Addition of higher African breadfruit and cashew nut significantly increased the protein, crude fibre, carbohydrates and minerals but it reduced the moisture and fat contents. The total nutrient present in the samples showed that it is a highly nutritious and delicious drink which will boost body immune system against diseases and it will support healthy living.

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Influence of Ohmic heating on the Proximate Composition and Consumer Acceptability Scores of African Breadfruit Seed Flour

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K E Y W O R D S

African breadfruit,
Aluminium electrodes,
Dehulling,
Ohmic heating,
Parboiling

A B S T R A C T

This work compared the effect of Ohmic heating (115V, 100°C) using aluminum electrodes and some sodium salts with conventional heating as a possible heat source for parboiling operation as it affects the nutritional quality of the dehulled African breadfruit seeds. The protein content ranged from 15.75-19.60%, fat content ranged from 5.97-7.54%, starch content ranged from 1.6-2.9 mg/ml while samples Ohmic heated with sodium chloride had the highest overall consumer acceptability score of 8.3 (on a 9-point hedonic scale), thus adjudged the best in this study.

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INTRODUCTION

The African breadfruit plant (*Treculia africana*) Decne is an evergreen tropical tree crop that bears large seeded fruits. It is well known in Southern Nigeria where the edible seed is of great socioeconomic value and forms an important part of diets. It contains between 13.4 and 23.3% proteins, 53.7 and 62.6% carbohydrates, 10.4 and 18.9% fats, and a wide array of nutritive elements (Ca, Zn, Fe, Mg), and antinutrient components of the seed (phytate, oxalate, tannin, and hydrogen cyanide) are drastically reduced during seed processing via fermentation, toasting, and boiling (Oyetayo and Oyetayo 2020). It is increasingly becoming commercially important in Southern Nigeria hence, Baiyeri and Mbah (2006) described it as an important natural resource which contributes significantly to the income and dietary intake of the poor. African breadfruit (*Treculia africana*) locally referred to as Ukwa in Igbo language; it is one of the many treasured economical plants. Its seed is commonly called "Afon" by the Yoruba, "barafuta" by the Hausa, "Ize" by the Benin, "eyo" by the Igala, and "Ukwa" by the Igbos of Nigeria (Emenonye and Nwabueze, 2016). The seeds are roasted and are useful as thickeners in soups and are eaten as snacks. The extracted seeds of *Treculia africana* are identified to become extremely healthy whenever it is correctly processed (Ejiofor *et al*., 1998). Diverse food forms could be produced from the seeds on the basis of custom, tradition, ethnic background (Nwabueze and Okocha, 2008).

In recent decades, technologies utilizing electrical energy directly into food (Ohmic heating) processing have attracted renewed interest in the food industry (Alkanan *et al.,* 2021). Ohmic heating, also known as Joule heating or electrical resistance heating, is performed by passing an alternating electric current through the food material. Heat is internally generated within a material due to resistance against the applied electrical current (*Makoto et al*., 2015). Microwave, infrared, infrared-microwave, microwave energy with halogen lamp heating, hot air assisted microwave heating, dielectric heating (Sumnu *et al.,* 2005) has been exploited in food processing operations. Whereas, food materials have been heated through various medium, Ohmic heating (OH) has long been exploited in industrialized countries as it brings about minimally processed food. This technique provides high-quality food and is also used in many applications such as pasteurization, sterilization, cooking, thawing, fumigation, extraction, and fermentation, in addition to the new trend for its use in military fields and food for long-term space missions (Alkanan *et al*., 2021). Studies have shown that the use of this technique does not lead to significant effects on the nutritional, functional, and synthetic properties and sensory characteristics of food products compared to traditional techniques (Alkanan, 2021). Ohmic heating is a high-temperature short-time (HTST) method, thus decreasing the possibility of high-temperature over-processing and its likely associated loss of nutrients and bioactive compounds. Another advantage of Ohmic heating is that it keeps delicately structured foods such as strawberries intact (Xiao *et al.,* 2017).

Despite the advantages of Ohmic heating of food products its use has been limited by the following:

- Lack of suitable electrode materials (Ruan *et al.,* 2001)
- Cost of electrical energy (Varghese *et al.,* 2014)
- Fear of electrocuting (Llave *et al.,* 2018)
- Improved performance at frequencies above 50 Hz (Shynkaryk *et al.,* 2010)

Although the technology of Ohmic heating appears to be promising and highly effective, there is little information in literature concerning the effect of this technique on a myriad of food products especially seeds, pulses and legumes. Unfortunately, in developing countries like Nigeria little is known about the usefulness of Ohmic heating in processing food materials. This work would compare the effect of Ohmic heating using aluminum electrodes and some sodium salts with convectional heating, thus drawing attention on the applicability of Ohmic heating as a possible heat source for parboiling operation on the dehulling of seeds, legumes and pulses using breadfruit as a model sample.

MATERIALS AND METHODS

Source of Materials

African breadfruit seeds were obtained from the breadfruit orchard of the Department of Forestry, Michael Okpara University of Agriculture Umudike in Abia State, while reagents were purchased from Hoslab Umuahia.

Experimental Design

The experimental Design was modeled as a randomised block design experiment having two variable (Convectional heating and Ohmic heating). Where the Ohmic heating experiment was carried out using 0.5% w/w of sodium salts *(Sodium chloride, Sodium sulphate, Sodium thiosulphate and Sodium metabisulphate at 0.5% w/w)* at 115volts for 15min at 100^{o}C using aluminum electrodes.

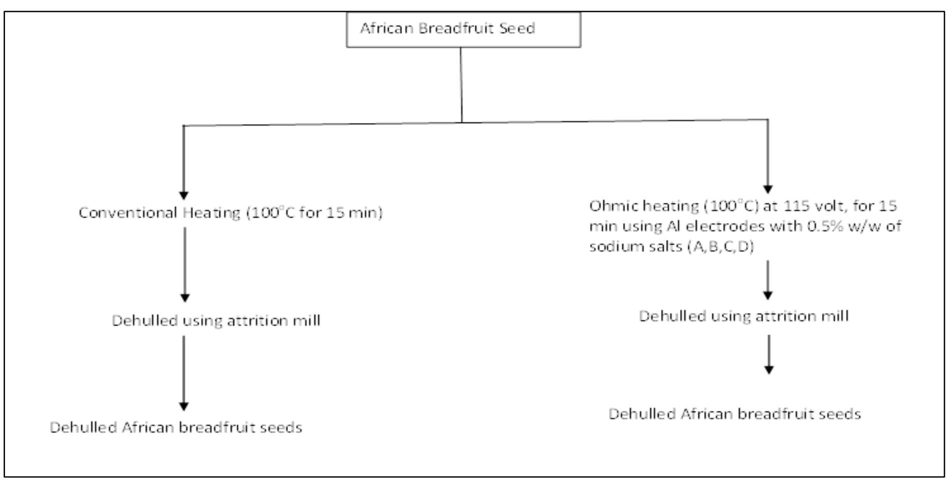

Fig 1: Production of dehulled African breadfruit seed flour

Note: Salt A = Sodium chloride; Salt B = Sodium sulphate; Salt C = Sodium thiosulphate; Salt D = Sodium metabisulphate. All the samples (Dehulled African breadfruit seeds) were oven dried (100^{o}C) milled and sieved with a 300 mill micron sieve and stored for further analysis.

Heating Methods

Convectional heating

Weigh 500g of African breadfruit seeds were sorted, wash under running water and conventionally parboiled at 100^{o}C for 15min. The seeds were cracked with a corona corn hand mill (*Ref. 121, Medellin-Colombia*) while still hot by adjusting the plates of the mill to allow the least impart between an un-parboiled seed and the plate. Cracked/dehulled seeds were sorted manually and oven dried (*Memmet, D 91126, Schwabach-Germany*) at 60^{o}C to constant weight, while seed pieces, undehulled whole seeds, undehulled seed pieces were separated and weighed for further analysis. The sample was milled with a locally fabricated disk mill and sieved with a 300μm pore size sieve. The flour produced serves as the control which was stored at ambient temperature (28-30^{o}C) for further analysis.

Ohmic heating

About 500 g of African breadfruit seeds were sorted, wash under running water and were Ohmic heated at 115 volts for 15 min at 100^{o}C using aluminum electrodes and sodium salts (*Sodium chloride, Sodium sulphate, Sodium thiosulphate and Sodium metabisulphate at 0.5% w/w*). The seeds were cracked with a corona corn hand mill (*Ref. 121, Medellin-Colombia*) while still hot by adjusting the plates of the mill to allow the least impart between an un-parboiled seed and the plate. Cracked/dehulled seeds were sorted manually and oven dried at 60^{o}C to a constant weight, while seed pieces, undehulled whole seeds, undehulled seed pieces were separated and weighed for further analysis. The samples were milled with a commercial mill. The milled sample was sieved with a 300 μm pore size sieve and stored at ambient temperature for further analysis.

Determination of Proximate Composition

Samples were evaluated for % moisture, % ash, % fat, % crude fibre % crude protein and % carbohydrate would be determined using the equation:

% carbohydrate = 100 – (% moisture + % ash + % fat + % crude fibre + % crude protein) as described by AOAC (2000).

Determination of Carbohydrate Components (Starch, Amylose and Amylopectin)

Starch content (mg/ml) was determined by the method of Radley (1976) as reported by Onwuka (2005).

Amylose content (%) was determined using the rapid calorimetric procedure as described by Onwuka (2005), while amylopectin (%) = 100 - % amylose.

Sensory evaluation

A consumer sensory panel of 20 semi-trained sensory panelists evaluated the quality features of the flour samples. They rated the samples on a 9-point Hedonic scale appearance, texture, flavour, saltiness and overall acceptability, with 9 representing strongly like and 1 representing extremely dislike.

Statistical Analysis

The Statistical Package for Social Science (SPSS) version 23.0 software was used to analyze the data. Duncans Multiple Range Test was used to detect significant differences ($p<0.05$) among the sample means using Analysis of Variance (ANOVA) and Least Significant Difference (LSD) for separation of significant means.

Plate 1: African breadfruit seed

Plate 2: Manual cracking of Conventional/Ohmic heated African breadfruit

Plate 3: Cracked, Dehulled kernel (whole and pieces) African bread fruit seeds

Plate 4: Dehulled African breadfruit seed (whole and pieces)

Table 1: Proximate composition of African breadfruit seed from conventional and ohmic heating

Proximate (%)	*Conventional heating 100°C*	*Ohmic Heating Aluminium electrode*				
		A	B	C	D	*LSD*
Moisture	3.58[a]	3.42[a]	3.93[a]	4.13[a]	3.88[a]	3.2356
Protein	18.69[a]	17.21[a]	19.23[a]	19.60[a]	15.75[a]	7.5965
Fat	7.54[e]	6.07[b]	6.63[c]	5.97[a]	7.43[d]	0.0586
Crude Fibre	0.15[a]	2.03[b]	3.67[d]	4.90[e]	2.63[c]	0.1847
Ash	2.61[b]	1.20[a]	8.40[d]	2.80[bc]	3.10[c]	0.3360
Carbohydrate	67.45[b]	70.05[b]	58.14[a]	67.21[b]	62.60[ab]	8.7122

A=Sodium Chloride, B= Sodium Sulphate, C= Sodium Thiosulphate, D= Sodium Metabisulphate. Means in the same row with different superscript are significantly different at ($p<0.05$)

RESULTS AND DISCUSSION

Proximate composition of African breadfruit seed from conventional and Ohmic heating

The results of proximate composition of the different treatments are summarized in Table 1. Significant differences ($p <0.05$) were not observed for moisture and protein content for all the treatments. Although the protein content of some of the ohmic heated samples (15.75, 17.21) were lower than that of convectional heating (18.69). This could be attributed to slight leaching and dehulling losses, although the protein content was relatively high and as such would be adequate to prevent protein energy malnutrition in people with breadfruit as their main protein source.

Furthermore, the fat content (%) of Ohmic heated samples was lower (5.97, 6.07, 6.63, 7.43, 7.43) as against 7.54 for conventionally heated sample: the brine of Sodium thiosulphate during the ohmic heating process produced the least fat content followed by Sodium chloride followed by Sodium sulphate and finally Sodium metabisulphate. Crude fibre contents (%) for Ohmic heated samples were significantly higher ($p <0.05$) than that of the control. Thus, we suggest that Ohmic heating could be of benefit during defattening operations and could retain fibre in foods where high fibre content is targeted.

Table 2 shows that the starch content was higher (2.9 mg/ml) for conventional heating as against ohmic heating (1.6 mg/ml). Although there was no literature to explain this observation but we reasoned that the significant difference ($p<0.05$) in carbohydrate components (Starch, Amylose, Amlopectin) could be due to the vigorous volumetric heating during ohmic heating.

Table 2: Carbohydrate Components of African breadfruit seed flour from conventional and Ohmic heating

CHO Components	*Conventional heating 100°C electrode*	*Ohmic Heating Aluminium*				
		A	B	C	D	*LSD*
Starch (mg/ml)	2.9[b]	1.6[a]	1.6[a]	1.6[a]	1.6[a]	0.6113
Amylose	39.49[b]	12.73[a]	14.11[a]	13.19[a]	13.46[a]	4.6008
Amylopectin	60.51[a]	87.27[b]	85.89[b]	86.81[b]	86.54[b]	16.258

A=Sodium Chloride, B= Sodium Sulphate, C= Sodium Thiosulphate, D= Sodium Metabisulphate. Means in the same row with different superscript are significantly different at ($p<0.05$)

The vigorous heating (Ohmic heating) promoted leaching of soluble nutrients (starch and amylose). It was also observed that ohmic heated samples have higher amylopectin content with no significant difference (p>0.05) amongst the Ohmic heated samples; this could be an indication of some levels of starch modification. Amylopectins are branched starch fraction which are resistant to retrogradation.

Products that have high amylopectin are said to possess outstanding paste clarity, high water-binding capacity, and resistance to gel formation and retrogradation; they are helpful in production of salad dressings, sauces, and pie fillings and in some canned goods; they are useful because of resistance to irreversible gel formation and syneresis on freezing and especially for many products stored in the frozen state (Cereal processing, 2010).

Table 3: Effect of Conventional / Ohmic heating on the Consumer Acceptability Scores of dehulled African breadfruit seed flour

Treatment	Appearance	Texture	Flavour	Saltiness	Overall Acceptability
C/H	7.4^{a}	7.4^{a}	7.3^{a}	6.9^{ab}	7.0^{a}
O/H (A)	7.9^{b}	7.8^{b}	8.1^{b}	8.4^{c}	8.3^{c}
O/H (B)	7.7^{ab}	7.7^{ab}	7.2^{a}	7.0^{b}	7.7^{b}
O/H (C)	7.6^{ab}	7.5^{ab}	7.3^{a}	6.6^{a}	7.3^{a}
O/H (D)	$7.b^{b}$	7.5^{ab}	7.4^{a}	8.2^{c}	8.2^{c}

C/H =Conventional heating. O/H=Ohmic heating, A=Sodium Chloride, B= Sodium Sulphate, C= Sodium Thiosulphate, D= Sodium Metabisulphate, Scored on a 9 point hedonic scale with 1 = dislike extremely, 2 = disliked very much, 3 = dislike moderately, 4=dislike slightly, 5 = neither like nor dislike, 6 = like slightly, 7 = like moderately, 8 = like very much, 9 = like extremely. Sores (9-7) = Positive / Liked; (6-4) = Neutral; (3-1) = Negative / Disliked. For each attribute, means in the same column with different superscripts are significantly different at p < 0.05.

Table 3 shows the result obtained from the Consumer acceptability scores of breadfruit flour produced from conventional/ohmic heating. We observed no significant difference (P<0.05) for the appearance of the flour samples. All the samples were liked (positive) (9-7) although, conventional heated dehulled African breadfruit seed had lower (7.4) appearance (sensory score) as against Ohmic heated samples (7.6-7.9). Whereas, no similar work come be sited. However, a few cooking experiments between conventional cooking and Ohmic cooking shows that Ohmic heated cauliflower had higher sensory scores (Appearance and Texture) when compared with that of conventional heating (Sandrine *et al.,* 2001). Lighter and less red colour for Ohmic cooked beef muscle *'biceps femoris'* (Markus *et al.,* 2009) and a good visually sensory quality for Ohmic cooked meatballs (Ilkin, 2013) have been reported.

From Table 3 the different treatments showed a slight significant difference at p > 0.05 for Texture. Van der Veer (1985) has enumerated the various functions of sodium chloride to include: (i) A functional role of improving texture. (ii) Reduction of growth of pathogens and organisms that spoil food products and reduce their shelf life. (iii) Improving taste and flavor.

Table 3 went further to shows the possibility of using Ohmic heating to improve the texture, flavour and saltiness of dehulled African breadfruit seeds flour. The overall acceptability showed that dehulled African breadfruit seed Ohmic heated (OH) (parboiled) with sodium chloride was mostly accepted, followed by samples Ohmic heated parboiled with Sodium metabisulphate, Sodium sulphate, Sodium thiosulphate and conventionally heated samples respectively.

CONCLUSION

The results revealed that the two parboiling methods (conventional and Ohmic heating) did not significantly (p>0.05) affect the protein content of the flour sample. Crude fibre contents were higher for Ohmic heated samples. African Breadfruit seed Flours samples produced with Sodium chloride salt had the highest overall acceptability score of 8.3 followed by the African Breadfruit seed Flour samples produced with of Sodium metabisulphate (8.2) while African Breadfruit seed Flours sample parboiled via conventional heating had the least overall acceptability of 7.0.

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Socio-economic Characteristics of Rice Farmers in Flood Prone areas of Niger State, Nigeria

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K E Y W O R D S

Disasters,
Flooding,
Incidents,
Multistage,
Standard of living

A B S T R A C T

The study analyzed effects of flooding on the socio-economic characteristics of rice farmers' in Niger State, Nigeria. A multi-stage sampling technique was used to select respondents for the study. A sample size of 234 registered rice farmers obtained was used for the study. Data collected were analyzed using descriptive statistics. From the results showed that average age of the respondents is 38years, male dominated in rice farming in the area. Majority (89.7%) of the farmers were married, average household size was nine (9) persons, 59% of rice farmers had formal education at various levels while 41% were illiterate. Further, majority (72.2%) of the farmers were peasant farmers. While1.3% practiced commercial farming in the area. Majority (79.9%) of the farmers had experienced flooding in their rice farm while 20.1% had not experienced flood in their rice farm and average annual income of the farmers was ₦509, 296.58. The study concluded that flood may have adversely affected farmers' social status in the study area.

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INTRODUCTION

Flooding in the 21st century in Nigeria has been a serious environmental problem in the rice industry. In recent years, Nigeria has been threatened with regular and extreme flooding reoccurrence which has led to enormous destruction of crops, livestock, houses and human lives. It was reported that over $16.9 billion was lost due to incidence of flood in 2012 alone which had adversely affected the standard of living of the farmers and the entire population (Oladokun and Proverbs, 2016). More so, in 2020, there was devastating flood in about 20 Local Government Areas of Niger State which mostly affected rice farm that led to significant decrease in the actual capacity of its production. The 2020 flood incidence in Niger State affected about 17, 000 communities and about 60,000 homes were pulled down as well as farmlands (Environ 2020).

Nigeria is endowed with abundant natural and human resources that if well harnessed will boost rice production to meet local consumption and surplus for export. Nigeria has a potential area for rice cultivation of about 4.6 to 4.9 million hectares, of which, only about 1.8 million hectares that is 35%, of the total land mass is under rice cultivation (Ismaila *et al.,* 2013; Chidiebere-Mark., 2019). Rice production yield in Nigeria is among the lowest within neighboring countries. However, Nigeria top in the production of rice in West Africa, but is also ranked second largest importer of rice globally (USDA, 2019). Rice stands better in contributing to national food security, income generation, poverty reduction and socio-economic well-being of Africa (Ismaila *et al.,* 2013).

Rice plays a vital role in ensuring sustainable food security as well as provision of employment and income to the nation's teeming population. Nigeria has been a major consumer and importer of rice in Africa. Indeed, rice is classified among the top four agriculture imports in Nigeria along with wheat, sugar and fish (Terwase and Madu, 2014). It has been reported that the country spends over ₦356 billion on yearly importation of rice, out of which about ₦1 billion is used per day (Oyediran, 2016). Rice production in Nigeria is mainly rain-fed and most of the farming activities are carried out along the water plain which increases their vulnerability to flooding. (Tiamiyu *et al.,* 2015). Thus, the study examined the effects of flooding on the livelihood of rice farmers in flood prone areas of Niger State.

METHODOLOGY

The Study Area

The study was carried out in Niger State of Nigeria. Niger State is located between Latitude 8°22'N and 11°30'N and Longitude 3°30'N and 7°20'E and covers a land area of about 76,363sq km, or about 8% of Nigeria's total land area. A Multistage sampling technique was used for the selection of respondents for this study. The first stage was purposive selection of two rice producing LGAs each from the agricultural zones I, II and II1 which are namely ;Lavun and Gbako, Paikoro and Bosso, and Wushishi and Mashegu respectively. The second stage also involved purposive selection of two rice producing villages that are mostly affected by flood and two rice producing villages that are less or not affected by flood from each of the selected LGAs. This gives a total of 24 villages selected for the study. The third stage employed Taro Yamane`s formula as adopted by Ibeziako (2017) to obtain an appropriate sample from the sample frame. A total of 234 respondents was selected from a total sample frame of 933(mostly affected = 467and less affected = 466) registered rice farmers. This comprised 117 households who were mostly affected by flood and 117 households who were less or not affected by flood at 0.08% and 92% precision and confidence level respectively.

RESULTS AND DISCUSSIONS

The socio-economic characteristics of the rice farmers are usually used to describe the behavioral factors of the farmers, which is a means of measuring their social status and financial worth's. The socio-economics of the respondents include age, gender, marital status, household size, educational level, farm size, rice farming experience, ever experienced flood in your rice farmland, annual rice farming income (Table1).

The Table showed that average age of the respondents is 38years. This implied that the majority of the rice farmers in the study area were in their active age for effective farming activities and they may likely to earn higher income. This is in agreement with the result of Abur, (2014) who carried out a study on Assessment of poverty status among rice farmers in Guma local government area of Benue State and reported that the rice farmers are in their active age and this can increase their income. The result revealed that majority about (85.5%) of the rice farmers were males compared to 14.5% females. This showed that male dominated in rice farming in the study area. This might probably be that female gender had hindrance to full participation in rice farming due to marital responsibilities coupled with culture and religious beliefs. This is in agreement with the findings of (Osanyinlusi and Adenegan 2016; Ajewole *et al.* 2018) Who reported that most of the rice farmers in their study area were male.

The result also revealed that majority (89.7%) of the rice farmers were married, while 10.3% were single. The implication is that there could be high supply of family labour which could reduce the cost of farming operations and increase the income of the farmers. This is in agreement with the result of (Osanyinlusi and Adenegan 2016). The result further revealed that the average household size was nine (9) persons. This is an indication that most of the rice farmers in the study area may likely had depended on family labour for their farming operations. This is because agricultural activities in the study area were labour intensive due to non-availability of machineries and this could reduce the variable cost of production. This is in agreement with the findings of Adedapo, *et al.* (2020). who reported that agriculture is labour intensive and large household size provides cheap labour.

The result also showed that 59% of the respondents had formal education at various levels while 41% were illiterate. Illiteracy could be a barrier to adoption of innovation that could have improved their production and productivity level. However, the educated rice farmers could easily adopt mitigating strategies against effects of flood in the study area as level of formal education is directly proportional to adoption of new and improved farming practices in the area which agrees with Jonathan *et al.* (2020) who reported that educational level of farmers makes it easier for adoption of new agricultural technologies in his study on Economic analysis of the effect of flood disaster on food security status of farming households in southern guinea savanna, Nigeria.

The result further revealed that majority (72.2%) of the rice farmers were peasant farmers, 26.5% practiced medium scale farming while1.3% practiced commercial farming in the area. This implied that most of the farmers were small-scale farmers. The result is similar with that of Chinaka and Udemezue (2015) who reported in their study on Adoption rate and potentials of improve cassava production technologies by farmers in Anambra state, that farmers in Anambra state were peasant farmers.

The average year of farming experience was 13. This revealed that the rice farmers in the study area had long period of farming experience which could enhance their farming practices. This is in agreement with the findings of Udemezue *et al.* (2019) who reported in their study that rice farmers had long farming experience in his study area. .Majority (79.9%) of the farmers had experienced flooding in their rice farm while 20.1% had not experienced flood in their rice farm. This was an indication that most of the rice farms were affected by flood incidence during the period. This is in line with the report of National Emergency Management Agency, (2021) that there was devastating flood incident between 2015 and 2020 in Niger State. Further, the average annual income of the farmers was ₦509, 296.58. The rice farmers with annual income range of between ₦801,000 and ₦1,200,000 claimed almost half (44.9%) of the total sampled rice farmers, those between ₦401,000 and ₦800,000 claimed 30.8% while those that fell between ₦100,000 – ₦400,000 claimed 24.3% of the total sampled rice farmers in the area. This implies that the farmers in the study area may probably had diversified to other source of income which had helped them to mitigate the effects of flood. However, judging by their average household size of nine(9) persons, There is indication that they may had be affected by flood incident in the area. This is in line with the report of National Emergency Management Agency, (2021) that there was devastating flood incident between 2015 and 2020 in Niger State.

Table 1 : Distribution of respondents according to their socio-economic characteristics

Variable	Frequency	Percentage	Mean
Age(Years)			
≤ 20	4	1.7	
21-40	144	61.5	38
41-60	84	35.9	
>60	2	9	
Sex			
Male	200	85.5	
Female	34	14.5	
Marital Status			
Single	24	10.3	
Married	210	89.7	
Household Size			
≤ 10	164	70.1	
11-20	67	28.6	9
>20	3	1.3	
Educational level			
No Formal Education	7	3.0	
Quaranic	4	1.7	
Adult	8	3.4	
Primary	23	9.8	
Secondary	77	33.0	
Tertiary	19	8.1	
Illiterate	96	41.1	
Farm size			
≤ 2	169	72.2	
2-3	62	26.5	
>4	3	1.3	
Farming experience			
≤ 15	159	67.9	
16-30	72	30.8	13
>30	3	1.3	
Flooding experience last farming season?			
No	47	20.1	
Years	187	79.9	
Annual farmer income			509,296.58
≤ 400000	57	24.3	
401000-800000	72	30.8	
801000-1200000	105	44.9	

Source: Field Survey 2021

CONCLUSION AND RECOMMENDATION

Base on this study, it can be concluded that rice farming in study area is dominated male. Looking at the farmers income compare to their average household size, there is indication that rice farmers in the area had be affected by flood in the study area. The farmers could have engaged in other source income which might had probably improved their income.

Therefore government should intervene by helping the rice farmers with irrigation facilities to increase their productivity and incomes to improve their standard of living.

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SUB-THEME 5

PLACE OF TECHNOLOGY AND ENVIRONMENTAL MANAGEMENT IN CLIMATE CHANGE ADAPTATION AND MITIGATION

Determinants of Environmental Responsible Behaviour among Undergraduate Students of College of Humanities and Culture, Osun State University, Nigeria

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KEYWORDS

Environmental awareness, Environmental issues, Environmental Behaviour, Conservation

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ABSTRACT

The environment plays a vital and important role in the life of human and their endeavors. There is scarcity of information factors that determine the behaviour of students. The research assessed the determinants of environmental responsible behavior among undergraduate students of College of Humanities and Culture, Osun State University, Osogbo, Nigeria. This research study adopted a descriptive research design, using a case study approach. Multi-stage random sampling technique was used. The sample size of 121 was obtained out of 1262 of the total numbers of students in the four randomly selected Departments. Chi-square was employed to test the significant relationship between student socio-economic characteristics and their environmental awareness and attitudes. Spearman rank correlation was also employed to test the significant correlation between environmental awareness and attitude of students. The result of the research showed that there was no significant relationship between students' socio-economic characteristics and their environmental awareness and attitudes at $p>0.05$. However, the study showed that there is significant correlation between environmental awareness and attitudes of students at $p<0.05$. The study concluded that environmental awareness has a powerful impact on environmental attitude and behaviour of the students, hence, recommends that environmental studies, degradation and conservation should be incorporated into student's curriculum to improve their positive attitudes towards the environment.

INTRODUCTION

Humans cannot perform any activity without the environment. The environment plays a vital and important role in the life of human and their endeavors whereby the environment benefit human if largely conserved and maintained. Human beings are responsible for the environmental pollution caused as a result of violating the laws of nature. Increased knowledge about the environment is assumed to a precondition for the attitude towards environment which can influence environmental policy (Oğuz *et al*., 2010). The importance of environmental education must be encouraged in higher education curricula (Arcury, 1990). Although people seem to be aware of the consequences that are existent in nature at a given time, yet people are hesitant to change their lifestyle even when the consequences are right around the corner.

The role of humans on the environment is prominent, they tend to be the major actor on the environment that use and control it. It is of a very crucial importance that humans have positive attitude, perception and behavior towards their environment because the environment is what constitutes their living. For years now, humans have mistreated and contaminated the very environment that sustains them. Thus, the broad concern for the environment can be so overwhelming that people do not know what to do or where to start making a difference. The list of issues surrounding our environment goes on, but there are some major ones that affect the majority of them overall: global warming and climate change; water pollution and ocean acidification; and loss of biodiversity (Hayta, 2006; Yardımcı and Kılıç, 2010). These major issues need immediate attention and proactive actions on human part to ensure conservation of the only habitable planet which we call our home.

Unawareness of people about the impact of environmental use on nature and environment itself also brings about these issues and even increasing. If the environmental problems that arise in this way are not prevented, it will be the end of life on earth (Yılmaz *et al*., 2002). Individuals' life and agricultural produce have suffered from these dangerous environmental problems which affect the texture and fertility of soil due to change in climate, causing excessive rain or unpredictable long dry season over a period of time, deforestation which leads to opening up the environment for easy washing of soil nutrients which leads to low agricultural produce. This effect may leads to poverty and poor malnutrition.

Environmental uses issue itself cannot be ignored, but has to be solved. Hence, the question here is "how can it be solved and from where do we start to solve the problem?" Understanding the root cause of the problem is necessary for accurate solution to be applied. The increasing environmental activities toward the end of the 1960s reached the peak with "Earth Day" in1970 (Thapa, 1999). Since then, there have been changes in the behaviour and attitudes of people toward environmental issues. However, while a majority of people have adopted environmental attitudes, environmentally responsible behaviors have not been reflected in life in the same level (Nouri *et al*., 2008; Chen *et al.*, 2010).

The aim of this study was to instill environment awareness and concern into people especially students, and also educate them on how to conserve and preserve the environment. Students have always played an active role in the activities leading to the development of environmental awareness. Therefore, several studies have been carried out to understand the determinants of environmental attitudes and behaviors of the students, in addition, the fact those students will be the ones who will manage and consume the future resources, hence, necessitated this study related to students.

METHODOLOGY

Study area

The study was conducted at the Ikire campus of the Osun State University, Osogbo, Osun State, Nigeria. The campus planning area lies within the tropical rain forest climate region with clear-cut hot and humid conditions during the rainy seasons. The onset of the rainy season in the area is characterized by strong winds. Rains are experienced over almost seven months of the year (April - October), while two months (November and December) are dry and dusty (Harmattan) and the three remaining months (January – March) fall within the hot and dry season**.** Temperatures in Ikire are as high as between 27-34°C. The mean annual temperature is about 27°C with a range of 4°C to 5°C. The coolest periods occur from April through December, coinciding with middle of the rainy and the harmattan seasons respectively. The highest temperatures are usually experienced between January and March, creating warm conditions. The planning Area lies from latitude 7°18' N - 7°30'N of the equator and 4°10'E - 4°20' E of the Greenwich Meridian. It covers 641,526,879.20 square meters land area and is bounded by major settlements and land mass such as Gbongan in the North-East; Shasa River and Ife North Local Government in the East; and, Osun River and Asejire in the West (UN-HABITAT, 2014).

Sampling Procedure and Data Collection

Multi-stage random sampling technique was used. At the first stage of the sampling, 50% sampling intensity was used to randomly select four Departments out of the eight Departments in the College. The selected Departments were English and International Studies, Linguistics and Communication Studies, Tourism Studies and Philosophy. At the second stage of the sampling technique, out of the four departments randomly selected, 10% sampling intensity was used to sample the respondents in each Department according to their level. The sample size of 121 was obtained out of 1262 of the total numbers of students in the selected Departments as described by Diaw *et al.* (2002). In this light, 121 questionnaires were administered to the Departments randomly selected where 41 structured questionnaires were administered to English and International Studies, 46 to Linguistics and Communication, 15 to Tourism Studies, and 19 to Philosophy Department.

Data analysis

Data of the study were analyzed using descriptive statistics (i.e., frequency, percentages, means and standard deviations) and inferential statistics by using a statistical analysis package SPSS 21. Chi square analysis was employed to test the relationship between socio-economic characteristics and perception of students about environmental issues. Statistical significance level was set at $\alpha=0.05$. Chi-square was also employed to test the significant relationship between student socio-economic characteristics and environmental awareness and attitude. Spearman rank correlation was used to test the correlation between environmental awareness and attitude of students.

RESULTS AND DISCUSSION

Perception of the Respondent on environmental issues

The categorization of the overall perception of the respondents with the environment was that 60.83% of respondent have positive perception about the environment while 39.17% of respondents have negative perception.

The result for categorization of undergraduate student in Ikire campus is positive. This is in line with Balakrishnan *et al.* (2020) who stated that Malaysian undergraduates have positive perception towards sustainable development of the environment. This is also in line with Direct Perception Theory (Hacker, 1991) and Theory of Instruction (Gagne and Dick, 1983) which claim that perception and attitude of an individual can be developed with the process of acquiring knowledge.

Undergraduate students' awareness of environmental issues

Based on their awareness as presented in Table 1, 49.2% of the respondent agreed that it is possible to modify the natural environment to suit their comfort, 34.2% strongly agreed and only 4.2 % disagreed. 37.5% of the respondents agreed that the ecological crisis facing human has been greatly exaggerated, 25% strongly agreed, while 13.3% disagreed with this. The categorization of the overall attitude of the respondents with the environment was that 55.0% of respondents have positive environmental attitude while 45.0% have negative environmental attitude. The result revealed that the students possess slightly higher positive environmental attitude which is 55.0%. This is in line with Gigliotti (1992) that students highly supported Environmental Attitude. This is also in line with the report of Praneetham *et al.* (2012) that the expressed environmental attitudes of students positively affected environmental behaviour.

Table 1: Environmental awareness of undergraduate student on environmental issues

Statement	SA	A	U	D	SD
It is possible for humans to modify the natural environment to suit their comfort	34.2	49.2	10.8	4.2	1.7
Mankind was created to rule over the rest of nature such as animals and the elements of environment	43.3	35.0	10.8	7.5	3.3
An imbalance in the elements of nature can be dangerous for living	29.2	43.3	8.3	18.3	0.8
The natural environment has the capacity to adjust itself to cope with the effects of our world of industrialization	25.0	32.5	13.3	22.5	6.7
The so-called "ecological crisis" facing humankind has been greatly exaggerated	25.0	37.5	17.5	13.3	6.6

Where; SA= strongly agreed, A= agreed, U= undecided, D= disagreed and SD= strongly disagreed

Relationship between students' socio-economic characteristics and their perception and awareness about environmental issues

Table 2 indicated that there was no significant relationship between students' socio-economic characteristics and their perception about environmental issues at $p>0.05$. This showed that socio-economic characteristics such as gender, religion, marital status, ethnicity, nationality, level and age have no significant influence on student's perception about the environment. The result also showed that there was no significant relationship between students' socio-economic characteristics and their environmental awareness and attitudes at $p>0.05$. This implied that socio-economic characteristics have no influence on students' environmental perception and awareness of the environment. This result is in line with Balakrishnan *et al.* (2020) who say the environmental sustainable development education in Malaysian higher education institutions played its significant role in educating undergraduate on environmental sustainability issue. This is also in line with Gregory's Theory of Perception (Hacker, 1991) and Theory of Instruction (Gagne and Dick, 1983) which claims that perception of an individual can be developed with the process of acquiring knowledge.

This result is in line with Niaura (2013) who stated that Respondents' gender, ethnicity, age, marital status and religious beliefs did not make a considerable impact on their environmental attitudes, awareness, intentions and actual behaviour.

Table 2: Relationship between socio-economic characteristics and their perception and awareness

	Gender	Marital Status	Age	Religion	Level	Nationality	Ethnicity
Relationship between socio-economic characteristics and Students' perception	1.023	2.654	5.050	2.077	4.127	5.457	3.978
	2	1	4	3	3	2	1
	0.881	0.265	0.070	0.413	0.553	0.084	0.546
Relationship between Socio-economic characteristics and Environmental awareness	0.227	2.124	3155	2.117	3.313	1.253	1.238
	2	1	4	3	3	2	1
	0.111	1.006	0.870	0.411	0.553	0.084	0.546

Source: Field Survey (2022), Significant at $p<0.05$

Correlation between students' environmental awareness and attitudes/behaviour towards the environment

Table 3 showed that there is significant correlation between environmental awareness and attitudes of students at $p<0.05$. This could be because environmental attitude is largely supported by environmental knowledge and environmental awareness. This result is in line with Ugulu *et al.* (2013) who observed that student attitude affect their behaviour, particularly their choice of action and persistence to give decisions.

Table 3: Correlation between environmental awareness and attitudes of students – Correlation

	X^2	Df	P	Decision
Correlation between environmental awareness and attitudes of students	0.277	3	0.000*	Significant

* = Significant at $p<0.05$**,** X^2=Chi-Square, Df= Degree of freedom, **Source:** Field Survey, (2022)

CONCLUSION AND RECOMMENDATION

The study concluded that environmental awareness has a powerful impact on environmental attitudes and behaviour of the students of the College of Humanities and Culture, Osun State University, Nigeria. Religion, age, gender and ethnicity were found not to influence environmental attitudes and perceptions of the students towards the environment. Environmental awareness was identified as the determinant of environmental attitudes and behaviour of the students. This study recommended that environmental studies, degradation and conservation should be incorporated into student's curriculum to improve their positive behaviour towards the environment.

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Potentiality Assessment of *Acidovorax sp*. and *Aeromonas sp.* for Degradation of Glyphosate and Paraquat Herbicides

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K E Y W O R D S

Bacteria,
Degradation,
Glyphosate,
Paraquat

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A B S T R A C T

In agriculture, weed control through chemical herbicides, creates spray drift hazards and adversely affects the environment. The search for an alternate method for the degradations of herbicides through the use of bacteria which is eco-friendly for the bioremediations of herbicides contaminated soil. This study aimed at assessing the biodegradation of glyphosate and paraquat herbicides by bacteria isolated from soil. Soil samples were collected from Research Farm of National Root Crops Research Institute, Ginger Station, Kajuru, Kaduna State, Nigeria. Bacteria were isolated and identified based on colonial and biochemical characteristics. The assessment for the potential of the bacterial isolates to degrade glyphosate and paraquat herbicides was carried out using microcosms study. The bacterial isolates were phenotypically identified as Proteus sp., Acidovorax sp., Micrococcus sp., Staphylococcus aureus, Bacillus sp. and Aeromonas sp. Among the isolates, Acidovorax sp. and Aeromonas sp. had the highest potential to utilize glyphosate and paraquat as sole source of carbon. In the presence of glyphosate Acidovorax sp. and Aeromonas sp. had cells count of 1.30×108cfu/g and 1.90×108cfu/g respectively. However, in the presents of paraquat as a source of carbon Acidovorax sp. and Aeromonas sp. had the counts of 1.90×107cfu/g and 2.60×106cfu/g respectively. The quantifications of glyphosate and paraquat herbicides residues in amended soil using GC/MS shows that Acidovorax sp. have degraded 77.1% while Aeromonas sp. 88.1% of glyphosate. However, Acidovorax sp. degraded 51.5% while Aeromonas sp. 59.8% of paraquat. This study showed that Acidovorax sp. and Aeromonas sp. had the potential to degrade glyphosate and paraquat herbicides.

INTRODUCTION

Herbicides are chemical substances or preparations designed to kill or inhibit the growth of plants, especially weeds. Herbicides are commonly used to control weeds in crop production. In addition, herbicides influence soil microorganisms responsible for numerous biological processes and crop production (Saleh, *et al*., 2020). However, excess use of herbicides in agricultural soils could contaminate the soil with toxic chemicals. When herbicides are applied, it is possible that certain chemicals may exert significant effects on non-target organisms such as soil bacteria (De-Lorenzo *et al*., 2001). Herbicides such as glyphosate and paraquat become incorporated in to soil directly during weed control and indirectly via water or residues of plant and animal origin. After applications, herbicides may evaporate (volatilize) and be washed away through surface run-offs or leached into deep soil strata (Kortekamp, 2011). Cost effective treatment and removal of such environmental pollutants become an essential part of environmental remediation. Some commonly employed methods toward the removal of glyphosate and paraquat herbicides residues from the soil include, chemical oxidation, photo oxidation, sorption, volatilization, leaching and biodegradation (Bogen *et al*., 2008).

Biodegradation is considered to be a cheaper, environmentally eco- friendly process involved in the remediation of glyphosate and paraquat contaminated soil (Yuan *et al*., 2002). The use of bacteria in the clean-up of the environment is the most suitable, non –toxic, economical and easy to carry out (Prakash and Irfan, 2011). Biodegradation is the process by which organic substances are broken down into smaller compounds by living microorganisms (Marinescu *et al*., 2009). Biological decontamination methods are preferable to conventional approaches because in general, microorganisms degrade numerous environmental pollutants without producing toxic intermediates (Olawale *et al*., 2011). Many bacteria that are able to degrade glyphosate and paraquat herbicides have been isolated from soil around the World (Desaint *et al*., 2000).

MATERIALS AND METHODS

Sampling Site and Collection

Soil samples were collected from Ginger Research Farm at the National Root Crops Research Institute, Maro, Kajuru Local Government Area of Kaduna State Northwestern Nigeria. The farm is located at Iburu along Kachia road 20 Km away from Kajuru town. Kajuru local government area is located on longitude 9º 59'N and 10º 55'N and latitude 7º 34'E and 8º 13'E with an area of 2464km^2 (GIS, 2021). The soil sampling was started 3m away from the entrance of the farmland. The soil samples were collected every 50m inside clean polythene bags. The soil samples were collected from four different sites using soil corer at a depth of 20cm. To ensure a fair representation of soil sample, the soil samples were collected in triplicate. The soil samples were transported to the Microbiology Research Laboratory of Bayero University, Kano for further analysis. In line with standard procedures as described by Dem (2007), the samples were air-dried and sieved through a pore size of 0.5mm brass sieve and stored at ambient temperature until further analysis (Dem, 2007).

The herbicides were purchased from a local agricultural dealer store in Kaduna. The herbicides are Paraquat and Glyphosate (Paraeforce and Force up respectively) and were identified and authenticated by comparing it with glyphosate and paraquat standard at the Department of Quality Assurance of the National Root Crops Research Institute, Umudike; Abia State, Nigeria. Paraquat contains 276g paraquat dichloride (200g paraquat ion) per litre. The Force up contains 360g glyphosate per litre in the form of 480 Grams per litre isopropylamine salt of soluble liquid (SL).

Isolation and Identification of Isolated Bacteria from Soil Samples

The isolates obtained from the soil by repeating sub culture of the bacterial colonies were identified using morphological, biochemical test and Molecular identifications (Todar *et al*., 2005).

Assessment of the Potential of the Isolated Bacteria to Degrade Glyphosate and Paraquat Herbicides

These were assessed in the laboratory using soil microcosm experiment (Pal and Das Gupta, 1994). Bacterial isolate obtained from pure culture were screened by inoculating the different bacterial isolates on a prepared solid mineral salt medium (MSM) enriched with 0.1% each of glyphosate and paraquat herbicides and incubated for 24 to 120 hours. The colonies were counted and isolates that recorded highest number of cells were considered for the assessment. Soil samples were collected and sterilized using autoclave at 121°C for 15 minutes. Soil samples (100g) was weighed into 500ml tapered bottles. A test soil in each tapered bottle was spiked with glyphosate and paraquat herbicides at a concentration of 6 mg kg-1 each and a control without herbicides. Five milliliters (5ml) suspension of a screened bacterial isolates equivalent to 0.5 Macfarland standard turbidity was added in to the respective bottles. A sterile distilled water was added to adjust to 60% water holding Potential (WHC) in each bottle. The experiment was monitored for a period of five weeks at a controlled temperature of 37 °C. Soil moisture contents was measure and maintain to constant weight by adding an appropriate amount of distilled water weekly (Pal and Das Gupta, 1994). At the expiration of five weeks of incubation, the soil (test soil) was taken for GCMS analysis for quantification of glyphosate and paraquat herbicides residues at Department Of Chemistry, Yobe State University, Damaturu.

Extraction of Glyphosate and Paraquat Herbicides Residues from Herbicides Amended Soil

One gram (1g) of glyphosate herbicide contaminated soil sample was extracted with 10mL of acetonitrile. The mixture was mixed at high speed using vortex mixer for 1min. Exactly 0.1 g of NaCl and 0.2g of activated anhydrous $MgSO_4$ were added to the mixture, and mixing continued for an additional 60 seconds. The mixture was centrifuged for 5 minutes at 5000 rpm. The supernatant was transferred to a 15 mL tube containing 2g $MgSO_4$. After shaking for 1minute and centrifuged for 5min at 5000 rpm, 4mL of the supernatant was transferred to a 5mL vial and evaporated to dryness. The residue was reconstituted by acetonitrile to obtain 1mL solution, and after shaking for 3minutes, 2µL of the solution was analyzed using gas chromatograph to determine the residues of glyphosate herbicide (Karyn and Ronald, 2012). Similar treatment was done for the paraquat amended soil sample.

GC/MS Analysis of Glyphosate and Paraquat Herbicides Residues from Contaminated Soil and the Ginger Rhizomes

Two microliters (2µL) of each of the solution (extracts) were injected separately into gas chromatograph to determine the herbicides residues. The GC/MS was equipped with helium as the carrier gas at a constant flow of 1 mL/minute. The oven initial temperature setting was 80°C for 3 minutes then ramped at the rate of 15°C/minute to 290°C and held for 5 minutes. Injection port was adjusted at 250°C and split less injection mode was used. After acquisition of the total ion chromate gram for the mixed stock standard solutions in scan mode, peaks were identified by their retention time and mass spectra. The most abundant ion that showed no evidence of chromatographic interference and had the highest signal-to-noise ratio was selected for quantification purposes (Karyn and Ronald, 2012).

RESULTS

The potential of the isolated bacteria to degrade glyphosate and paraquat and use it as carbon and energy source for the increases in bacterial populations were presented in Table 1. The two bacteria (*Acidovorax* sp. and *Aeromonas* sp.) were found to have the highest potential ability to utilized glyphosate and Paraquat herbicides as carbon source. *Acidovorax* sp. and *Aeromonas* sp. shows cells count of 1.30×10^{8}cfu/g and 1.90×10^{8}cfu/g respectively in the presents of glyphosate while *Proteus* sp. (2.30×10^{6}cfu/g), *Micrococcus* sp. (1.40×10^{6}cfu/g), *Bacillus* sp. (1.20×10^{6}cfu/g) and *Staphylococcus* sp. (1.11×10^{6}cfu/g). However, in the presents of paraquat as a source of carbon *Acidovorax* sp. and *Aeromonas* sp. has the counts of 1.90×10^{7}cfu/g and 2.60×10^{6}cfu/g respectively as shown in table 1.

Table 1. Potentiality of the Isolated Bacteria to Utilize Glyphosate and Paraquat Herbicides for Growth

Bacteria	Glyphosate Herbicide	Paraquat Herbicide
Proteus sp.	2.30×10^{6}cfu/g	1.10×10^{5}cfu/g
Acidovorax sp.	1.30×10^{8}cfu/g	1.90×10^{7}cfu/g
Micrococcus sp.	1.40×10^{6}cfu/g	1.80×10^{5}cfu/g
Bacillus sp.	1.20×10^{6}cfu/g	1.70×10^{5}cfu/g
Staphylococcus sp.	1.11×10^{6}cfu/g	2.90×10^{5}cfu/g
Aeromonas sp.	1.90×10^{8}cfu/g	2.60×10^{6}cfu/g

Glyphosate residues in soil and their percentage degradations by the bacterial isolates is presented in Table 2. The results reveals that, the highest percentage degradations was recorded in treatment B (Soil + Glyphosate + *Aeromonas* sp.) with percentage value of 88.1% while treatment A (Soil + Glyphosate + *Acidovorax* sp.) and C (Soil + Glyphosate + *Acidovorax* sp. + *Aeromonas* sp.) were 77.1% and 70.6% respectively. The D (Control) soil had percentage value of 11.9% only (Table 2.).

Table 2. Percentage Degradation of Glyphosate Herbicide

Treatments	Initial concentration (6mg/kg)	Final concentration (6mg/kg)	Percentage degradation (%)
A	0.109	0.025	77.1
B	0.109	0.013	88.1
C	0.109	0.032	70.6
D (Control)	0.109	0.096	11.9

Key:A= Soil + Glyphosate + *Acidovorax* sp., B= Soil + Glyphosate + *Aeromonas* sp., C= Soil + Glyphosate + *Acidovorax* sp. and *Aeromonas* sp. And D= Soil + Glyphosate (Control)

Paraquat resdues in soil and their percentage degradations by bacteria (*Acidovorax* sp. and *Aeromonas* sp.) were assessed. The highest percentage degradations was recorded in treatment C (Soil + Paraquat + *Acidovorax* sp. + *Aeromonas* sp.) with values of 61.9% and the control treatment D (Soil + Paraquat) had the least percentage degradation (8.2%) (Table 3.).

Table 3. Percentage Degradation of Paraquat Herbicide

Treatments:	Initial concentration (6mg/kg)	Final concentration (6mg/kg)	Percentage degradation (%)
A	0.097	0.047	51.5
B	0.097	0.039	59.8
C	0.097	0.037	61.9
D (Control)	0.097	0.089	8.2

Key: A= Soil + Paraquat + *Acidovorax* sp., B= Soil + Paraquat + *Aeromonas* sp., C= Soil + Paraquat + *Acidovorax* sp. and *Aeromonas* sp. And D= Soil + Paraquat (Control)

DISCUSSION

Biodegradation is the process by which organic substances are broken down into smaller compounds by living microorganisms (Marinescu *et al*., 2009). The use of bacteria in the degradation and detoxification of many toxic xenobiotics, especially glyphosate and paraquat herbicides, is an efficient tool for the decontamination of polluted sites in the environment (Mohammed, 2009). Glyphosate and paraquat herbicides used in this research show an effects on growth and development of *Acidovorax* sp. and *Aeromonas* sp. The highest increase in bacterial counts was observed in the presence of glyphosate when compared with the paraquat. Glyphosate was reported to be less toxics than paraquat due to the presence of phosphate group in their structural formular while paraquat contains ammonium compound. According to Carlisle and Trevors (1988), glyphosate and paraquat can either stimulate or inhibit soil microorganisms depending on the soil type, herbicide concentration and environmental conditions. In relation to degradation of herbicides, it was observed that, the highest degradations was recorded in glyphosate using *Aeromonas* sp. in comparison with paraquat. This might be due to the fact that glyphosate was observed to be less toxic than paraquat to the bacterial cells and this findings were supported by other studies (Turkington, *et al*., 2001; Wyss and Muller-Scharer, 2001; Anderson and Kolmer, 2005). However, few studies contradicts this result (Wardle and Parkinson, 1990; Busse *et al*., 2001; Weaver *et al*., 2007).

This finding is in line with Isenring (2006) that paraquat inhibit several microorganisms in soil. They reported that paraquat could inhibit a great number of cellulolytic microflora and that might cause injurious effects to symbiotic, anaerobic and nitrogen fixing microorganisms. Paraquat is also known to be bounded strongly and coherently to soil components, including clay minerals and organic matter and therefore these limits the access of microorganisms to paraquat in soil water (Bromilow 2003; Isenring, 2006). Thus, adsorption of paraquat to soil rapidly decreases the bioavailability of the herbicide in the soil environment and demonstrated the capability of adsorption process to deactivate hundreds or even thousands of paraquat application over many soil types (Roberts, *et al*., 2002). The sandy loam characteristics of the experimental soils might have reduced the binding of paraquat to soil components and thus increasing the availability of paraquat in soil water, and hence affecting the soil microorganisms significantly. Conclusively, thus, the bacteria (*Aeromonas* sp. and *Acidovorax* sp.) can be exploited for biodegradation of glyphosate and paraquat and should be further studies for their ability to degrade other classes of herbicides.

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Potentials of Urban Trees and their Roles in Carbon Sequestration

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ABSTRACT

Trees in the urban environments play an essential public health role because of their ability to absorb atmospheric carbon di oxide (CO_2) through photosynthesis and thus, stored CO_2 as tree biomass. Increase in population growth, industries, automobile uses, urbanization, cooking as well as concrete landscape have continued to degrade the natural environment, increasing heat and increasing the amount of greenhouse gas emissions such as CO_2 in the Urban environment. Hence, there is a need to improve urban green efforts. This work reviewed the potentials of urban trees and their role in carbon sequestration. Several approaches have been used to investigate the ability of urban trees to sequester carbon. Their ability to increase carbon sequestration and storage for climate change mitigation actions cannot be overemphasized. Studies have revealed that apart from the direct storing of carbon by urban trees, they as well reduce CO_2 emissions by cooling ambient air and allowing residents to minimize annual heating and cooling. Carbon dioxide concentration due to vehicular emission can also be minimized with roadsides trees. Studies have also exposed that when trees are planted near buildings, they can indirectly reduce carbon emissions by moderating the amount of energy that is required for space cooling. This work concluded that urban dwellers need to recognize and articulate the prominence of trees as a vital component of the urban setting. The selection of different tree species with high biomass and efficiency of trapping and fixing carbon is therefore recommended in plantation programme in urban areas.

INTRODUCTION

The volume of trees to engross carbon dioxide (CO_2) and additional conservatory gases from the atmosphere is known as Carbon sequestration. There is increase in the concentration of CO_2 in the atmosphere which increases anxiety because it is the major greenhouse gas responsible for global warming (IPCC, 2009). CO_2 is the greatest protuberant constituent of anthropogenic greenhouse gas productions, causing primarily from fuel combustion in the urban environment. Increases in human activities such as population growth, industries, auto mobile usage, cooking among others contribute to the growth rate of atmospheric carbon dioxide.

Growth in population with consequent increasing vehicular traffic also has propensities to result in high levels of carbon dioxide in an environment (Bada *et al.*, 2018). Trees alleviate air pollutants and such roles in urban ecosystem need to be taken conscious of as the greenbelt acts as hotspots in urban biodiversity (Sharma *et al.*, 2021). Urban trees or vegetation (Kuronuma and Watanabe, 2017) are believed of as an operational ways to mitigate city millennium ecological problems with the comprehended benefits that include urban heat island effect mitigation (Ugle *et al.*, 2010)

Trees do not only have impact on local and regional air quality by fluctuating the atmospheric environment, sinking temperature and other microclimatic effects, dwindling and maintaining air contaminants, and giving cooling effects; nevertheless, also help to resolve, absorb and adsorb particle pollutants that could damage human inhalation tracks, sequester CO_2 and other repugnant gasses and replace the atmosphere with sufficient oxygen (Ondono *et al.,* 2016; Bada *et al.,* 2018). Trees have the capacity to sequester CO_2 through photosynthesis, and can store carbon in the soil (Ngo and Lum, 2018) and in tree biomass.

Carbon storage, as assessed based on tree biomass production, is an effective technique for dwindling the amount of greenhouse gases in the atmosphere (Ritson and Sochacki, 2003; Bada *et al.,* 2018**).** Green areas in the city may significantly affect local concentrations of atmospheric CO_2, showing lower CO_2 concentration in the presence of vegetation. This work therefore reviewed the potentials of urban trees and their roles in carbon sequestration.

Factors responsible for urban increase in carbon dioxide (CO_2) emissions

According to Hoornweg *et al.* (2011) the atmospheric concentration of carbon dioxide has increased dramatically since the start of the industrial revolution. Close to 280 ppmv (parts per million by volume) in 1870, the average global concentration surpassed 400 ppmv for the first time in May 2013. The amount of CO_2 concentration is also growing: from 0.7 ppmv per year recorded in the early 1960s, it rose to 2.0 ppmv per year between 2000 and 2010. This rushing is similar to the rise in fossil CO_2 emissions, due notably to the use of fossil fuels (primarily coal, oil and gas). Cities are responsible for more than 80% of global greenhouse gas emissions (Hoornweg *et al*., 2011).

In Nigeria, Bada *et al.* (2018) in their study reported that industries and vehicular emissions have the tendencies to result in high levels of carbon dioxide in an environment. Ugle *et al.* (2010) reported that cities are net producers of carbon dioxide and have lower amounts of stored carbon.

Ramachandra *et al.* (2015) in their study in the main cities of India, reported that transportation sector was found to be the main source of CO_2 in the urban atmosphere, followed by the domestic and industrial sectors.

In Seoul, Park *et al.* (2013) described peak concentrations and emissions of CO_2 in the early morning and afternoon, in response to the large-scale use of liquefied natural gas for cooking and heating by residents surrounding the measurement site. According to the report of Henninger (2008) on his study in the city of Essen, Germany, more than 70% of the near-surface urban CO_2 was found to be affected by traffic density and atmospheric stability.

Roles of urban trees in carbon sequestrations

Studies have shown that asides struggle to decrease the release of CO_2 in the atmospheres of cities; it is also possible to absorb carbon from the atmosphere and cumulatively trapped it in different components of the urban environment (Ariluoma *et al.*, 2021). This possibility of capturing and trapping carbon is shown in Figure 1 as described by Hyvönen *et al*. (2007) and Fares *et al*. (2017). This application of CO_2 is referred to as carbon sequestration, and urban trees in parks and forested areas can in fact remove and store large amounts of carbon in belowground and above-ground woody biomass (Ngo and Lum, 2018). Akbari and Konopacki (2005) also reported that when trees are planted near buildings, they can indirectly reduce carbon emissions by moderating the amount of energy that is required for space cooling.

Bada *et al.* (2018) examined carbon sequestration potential of roadsides trees in Abeokuta, Ogun State, Nigeria. They reported that the non-green spaces zones had ($p < 0.05$) higher CO_2 and other gases compared to the green spaces zones. Their research revealed that the highest Above Ground Biomass (ABG) value of 66.82×106 kg m^2 was estimated in *Azadirachta indica* while highest carbon sequestration of 14273.00 kg m^2 was calculated for *Gmelina arborea*. The study concluded that carbon dioxide (CO_2) concentration due to vehicular emission reduced with roadsides trees.

According to Lai and Augustine (2012) and Nowak (2010), urban trees influence local climate, energy use, carbon cycles and climate change. Other factors that influence the total amount of carbon sequestered by urban trees include: the disposal or use of trees for building construction, number of trees and their spatial coverage, interaction with the soil, age and health and mortality rate. Urban trees can be used to investigate the general condition of any environment. It is a determinant of how anthropogenic activities affect environmental conditions in any cities, assuming that the atmospheric concentration will continue to rise due to anthropogenic emissions. Despite extensive evidence of the critical role played by urban trees in city environments, urban planners and architects have often undervalued the role played by trees.

Ugle *et al.* (2010) and Calfapietra *et al.* (2015) reported that if the cities of the future must be made more sustainable, man must learn to minimize and manage some ecological effects such as urbanization which affects hydrology as well as increase in biodiversity. These will help urban trees to sequester CO_2 under future climates if taken into consideration.

- There are other important benefits of urban trees which are:
- Enhancement of urban climate excesses and mitigation of urban heat islands
- Stock and repossess carbon
- Reduce noise pollution and improve air quality
- Reduce consumption of electricity for heating and cooling
- Aesthetic contribution, scenic beauty, visual amenity, and improve property value
- Contribute to human health and relaxation, reduce stress and anxiety levels

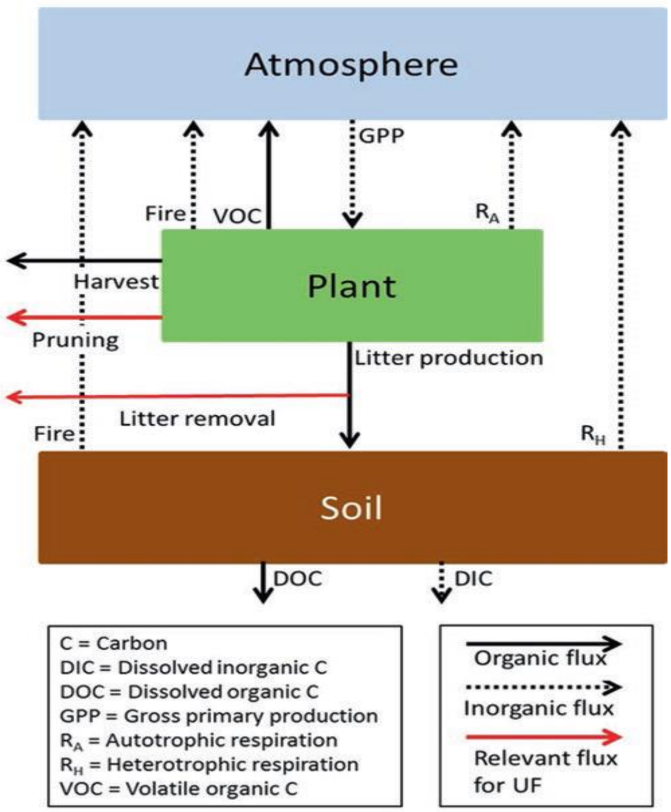

Figure 1: Carbon flow in the soil-plant-atmosphere continuum. Carbon is exchanged in both organic and inorganic form. Red arrows show C fluxes of particular interest in urban forests where trees are managed more intensively with pruning and litter removal (Hyvönen *et al*., 2007; Fares *et al*., 2017).

Carbon Sequestration Potential of urban trees

Urban trees offer various ecosystem services to urban dwellers which include carbon storage and sequestration. During photosynthesis, trees transform carbon dioxide and water into sugar molecules and oxygen, some of this sugar is stored, while most of it gets used by the tree for other purposes such as energy and structure (Nowak and Crane, 2002). One tonne of carbon storage in the tree therefore represents removal of 44/12 or 3.67 tonnes of Carbon from the atmosphere, and the release of 2.67 tonnes of oxygen back into the atmosphere (Nowak and Crane, 2002). Carbon sequestration and storage by trees have been acknowledged as the foremost contributor to carbon soil sequestration of green infrastructure.

The carbon binding capacity and storage are directly dependent on the leaf area and biomass of a plant, and thus over different vegetation types, trees contribute to carbon storage highest (Calfapietra *et al.,* 2015). Sharma *et al.* (2021) revealed that trees have the highest ability for carbon sequestration because of the large biomass whereas the impact of other greenery is small. However the quality and depth of growing medium of other vegetation types impact on the overall carbon storage potential. In particular, a significant increase in carbon storage is achieved by adding biochar to the growing media of all vegetation types Ariluoma *et al.* (2021).

According to the report of Ariluoma *et al.* (2021) optimizing the number of tree species would increase the total carbon sequestration of trees by 95% during 50 years depending on sun and shade conditions. Eneji *et al.* (2014) reported that *Azadirachta indica* and *Albizia lebbeck* stored 5448.8 kg C and 1040.4 kg C respectively in their study area in Nigeria. Ajani and Shams (2016) revealed that *Azadirachta indica* stored 662.3 kg C, and *Conocarpus erectus* 192.7 kg C in their study in Pakistan. Bada *et al.* (2018) also investigated carbon sequestration potential of urban trees in Abeokuta, Nigeria. They reported that the non-green spaces zones had higher CO_2 and other gases compared to the green spaces zones. Their study concluded that carbon dioxide (CO_2) concentration due to vehicular emission reduced with roadsides trees.

In India, Sharma *et al.* (2020) revealed that *Ficus benjamina* can sequester 30.53 tons of carbon. Al-Nadabi and Sulaiman (2023) also reported in their study to screen the tree species diversity in planted vegetation areas for the carbon storage potential that the highest contribution of carbon sequestration (CO_2 equivalent) is dominated by *Ficus spp.* (30.3%) with a total of 3399.3 tCO_2eq, followed by

Azadirachta indicia (25.4%) with a total of 2845.2 tCO_2eq and *Conocarpus erectus* (20.4%) with a total of 2286 tCO2eq. The whole study site had the ability to sequester about 11,213.3 tCO_2eq and 3.9 ± 0.1 tCO_2eq on average. They also reported that it is important have vegetation that can be able to store carbon for sustainable environmental preservation of urban areas.

CONCLUSION

Urban residents need to understand the importance of urban trees as a vital component of the urban landscape especially on their potentials to sequester carbon dioxide as well as other noxious gases in the urban atmosphere. Greater attention is needed to be paid to the selection of trees to be planted in urban environment, not just with a view to easy maintenance, but to select an appropriate mix of trees. These trees will bring about ecological integrity and ability to sequester carbon in legible landscapes. This work revealed that an urban trees function in sequestering atmospheric carbon is very imperative. Therefore, the selection of tree species with high biomass and high efficiency of carbon fixation in afforestation programme in urban areas and institutional areas is highly recommended.

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Response of Turkey Growers Fed Fermented Shea Butter Cake Based Diets with Fullzyme® Supplementation

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ABSTRACT

A 6-week experiment was conducted to evaluate the growth performance and economic analysis of broad breasted bronze turkey growers fed diets containing fermented shea butter cake meal (FSBCM) as replacement for maize with Fullzyme® supplementation. Three treatment diets were formulated, where T1 contained maize-soybean based control diet, T2 had 25% FSBCM replacing maize in T1 diet and T3 contained 0.5% Fullzyme supplementation to T2 diet. A total of 72, six-week old unsexed broad breasted bronze turkey growers were weighed and allocated to three dietary treatments with four replications of six birds each in a completely randomized design (CRD). Data collected on feed intake, body weight gain and feed:gain as well as cost indices were subjected to analysis of variance with the aid of SAS software package. Feed and water were provided ad libitum. Results showed that significant ($P<0.05$) higher weight gain and lower feed intake were recorded in turkeys fed control and T3 diets compared to those offered T2 diet. Feed:gain deceased ($P<0.05$) in turkeys fed control and T3 diets than those fed T2 diet. Cost analysis revealed that cost/kg gain was significantly ($P<0.05$) lower in turkeys fed T3 diet compared to those on control and T2 diets. Cost of feed consumed, cost of production and % feed cost were higher ($P<0.05$) in control group than T2 and T3 groups. In conclusion, FSBCM can replace maize in turkey growers diet up to 25% level with mixture of enzymes cocktail and probiotics (Fullzyme) supplementation without compromising growth performance at a lower feed cost/kg weight gain.

INTRODUCTION

The increasing surge in population growth has caused an increase in global demand for animal protein especially consumption of poultry meat in developing countries. The need for increased animal protein consumption of the rural and urban Nigeria populace in the face of rising population and inflation has resulted in the increase in cost of conventional feed ingredients (Agbogidi and Okonta, 2011; Oguntoye *et al*., 2018). Feed accounts for 75-80% of the total cost of poultry production in Nigeria and this is largely due to the high cost of conventional feed stuffs stemming directly from their high demands as staple food by humans (Onu *et al*., 2011). In Nigeria, the poultry feed industry is heavily dependent on grains such as maize, millet and sorghum; and oilseed resources such as groundnut cake, soybean cake, cotton seed cake and palm kernel meal. It has therefore become imperative to explore other alternatives for poultry farmers and feed industry in order to reduce the current stress on human food supply, enhance production of food sustainability at least cost, without compromising the environment, minimize hunger and malnutrition.

One of such alternative and potential feed resource is shea butter cake (SBC), a by-product obtained from processing shea nut into shea butter, and has always been discarded as waste and unusable by man and any conventional industry. Chemical composition analysis of SBC indicated its overall nutritional value to be high but its inclusion in poultry diet has been limited due to the occurrence of antinutritional factors (ANFs) such as tannin, bromine and saponin (Annongu *et al*., 1996; Atuahene *et al*., 1998; Orogun *et al*., 2015). Some researchers have reported the effectiveness of fermentation treatment of SBC in increasing its nutritive potential by reducing the level of these ANFs contained in the cake meal (Agbo and Prah, 2014; Matthew *et al*., 2018; Aguihe and Kehinde, 2019). Also, the incorporation of SBC in poultry diets has been challenged by its highly fibrous nature that can cause poor performance and health of birds (Dei *et al* 2008; Oddoye *et al*, 2012; Orogun *et al*., 2015). Consequently, appropriate application of supplemental feed additives such as enzymes and probiotics are well documented as effective means to improving the nutritive value of fibrous plant based ingredients through increased nutrient digestibility and beneficial microbial population in the digestive tract of birds (Wealleans *et al*., 2017; Singh *et al*., 2019; Aguihe *et al*., 2020; Luo *et al*., 2022; Shekarabi *et al*., 2022). Although the application of multienzymes and probiotics in poultry ration has gained wide attention, until recently, there is dearth of information on the impact of their combined supplementation in growing turkey birds fed SBC based diet. Therefore, the present study was conducted to evaluate the combined effect of multienzymes and probiotic supplementation in diets of turkey birds containing fermented SBC meal on growth performance and cost benefit.

MATERIALS AND METHODS

Experimental site and preparation of test ingredient: The experiment was carried out at the Poultry Unit of the Teaching and Research Farm of the Department of Animal Production Technology, Federal College of Wildlife Management, New-Bussa, Niger State. The SBC were obtained from some local shea butter processing factories in New-bussa, thoroughly mixed and subjected to fermentation under anaerobic conditions for five days. Thereafter, the fermented SBC were properly air dried for 3 days and then pulverized into finer particles to produce fermented shea butter cake meal (FSBCM), and thereafter subjected to proximate analysis using the procedure of AOAC (2016) as shown in Table 1.

Table 1: Proximate composition of fermented shea butter cake meal (FSBCM)

Nutrients (%)	Dry matter	Ash	Crude fiber	Crude protein	Crude fat	NFE
FSBCM	95.61	6.13	3.36	15.85	24.25	46.03

Experimental birds, design and management: A total of 72, six-week old unsexed broad breasted bronze turkey growers were weighed individually and allocated to three dietary treatments with four replications of six birds each in a completely randomized design (CRD). Feed and water were given *ad-libitum*. Data on feed intake and body weight were collected on weekly basis. The birds were raised for a period of 42 days in a deep litter system using wood shavings as litter material and kept in an open sided poultry pen facility.

Experimental Diets: Three isonitrogenous and isocaloric experimental turkey grower diets were formulated such that diet T1 which served as the control contained corn-soybean meal based while diets T2 contained 25% FSBCM replacing maize in T1 and diets T3 contained 0.5% Fullzyme® supplementation to diet T2. Table 2 shows the ingredient composition of the experimental diets.

Ingredient composition of Fullzyme®: Fullzyme® is a unique blend of mixture of concentrated exogenous enzymes cocktail (amylase, protease, cellulase, lipase, pectinase, xylanase, β-mannanase, β-glucanase, phytase, *Aspergillus oryzae*) and probiotics (yeast culture, and *Bacillus subtilis*), produced by Biofeed Technology Inc., Brossard QC, Canada. Fullzyme® was added at the rate 50g to 100kg of the diet according to the Biofeed guidelines.

Data collection: The turkey birds were weighed at the beginning of the experiment and weekly, subsequently. Body weight gain was determined as the difference between two consecutive weighing (1-week interval). Feed intake was obtained as the difference between the quantity offered and quantity not consumed. Feed conversion ratio (FCR) was calculated as feed intake divided by weight gain. Financial benefit was computed using the market cost of the ingredients as at the time of the study to estimate the cost per kg diets and other cost parameters were determined using the procedure as described by Oguntoye *et al*. (2018).

Statistical Analysis: Data generated was subjected to Analysis of variance (ANOVA) using the general linear model in a statistical analysis system (SAS, 2002). Existence of significant differences among the treatment means were separated using Tukey test and level of significance was adopted at probability level of 5%.

Table 2: Ingredient composition of experimental diets

Ingredients (kg)	T1 (0% FSBCM)	T2 (25% FSBCM)	T3 (25% FSBCM+FZ*)
Corn	44.00	33.00	33.00
Soybean	32.30	32.30	32.30
Fishmeal	5.00	5.00	5.00
Wheat offal	9.50	9.50	9.00
Groundnut oil	5.00	5.00	5.00
FSBCM	0.00	11.00	11.00
Di-calcium phosphate	1.50	1.50	1.50
Limestone	1.00	1.00	1.00
Salt	0.30	0.30	0.30
Methionine	0.40	0.40	0.40
Lysine	0.50	0.50	0.50
Premix	0.50	0.50	0.50
Fullzyme®	0.00	0.00	0.50
Total	100.00	100.00	100.00
Calculated Composition			
Crude protein %	22.55	22.39	22.62
ME Kcal/kg	3118.10	3182.55	3155.77

*FSBCM: Fermented shea butter cake meal; FZ: Fullzyme®

RESULTS AND DISCUSSION

The effect of Fullzyme supplementation to FSBCM based diets fed to turkey growers on growth performance is presented on Table 3. The result showed that Fullzyme supplementation significantly affected (P<0.05) final body weight, feed intake, body weight gain and feed:gain of the birds. Birds fed T2 diet showed higher (P<0.05) feed intake compared to those on the control diet while birds fed T3 diet had the lowest (P<0.05) feed intake. Body weight gain of the birds was significantly (P<0.05) higher in the control diet than those fed T2 diet. The weight gain of birds fed T3 diet did not differ (p>0.05) from those offered control diet. Feed:gain ratio was significantly improved (P<0.05) in birds fed control and Fullzyme supplemented FSBCM diet (T3) than those fed FSBCM diet without Fullzyme addition (T2). The improvement in weight gain and feed:gain of broiler chickens fed diets supplemented with Fullzyme as observed in this study is in line with previous reports that demonstrated a positive interaction of broiler chickens fed enzymes and direct-fed microbials on increased body weight gain and decreased feed:gain (Oladipo *et al.,* 2019; Aguihe *et al.,* 2020; Abdel-Ghany *et al.,* 2020; Luo *et al*., 2022). The dual objectives of using exogenous digestive enzymes and probiotics are associated with enriching the microbial balance in the GIT by increasing the abundance of beneficial bacteria while decreasing pathogenic microorganisms (Dai *et al*., 2019; Luo *et al*., 2022; Sun *et al.,* 2022). Thus, incorporating dietary probiotics and exogenous enzymes improves nutrient availability and intestinal health, and helps maintain a more balanced microbiome diversity (Wealleans *et al.,* 2017; Oladipo *et al*., 2019; Shekarabi *et al*., 2022). The enhancement in the growth performance observed in turkey growers could be related to the improved digestion capacity in the intestines by synergetic action of dietary multi-enzymes and probiotics (Singh *et al*., 2019; Abdel-Ghany *et al*., 2020; Luo *et al*., 2022).

Table 3: Effect of enzymes cocktail and probiotic mixture on growth performance in turkey growers fed fermented shea butter cake based diets

Growth indices	T1	T2	T3	SEM	p-values
Initial body weight g/bird	1300.00	1330.00	1300.00	0.04	4.987
Final body weight g/bird	2430.00^{a}	2286.00^{b}	2395.50^{a}	18.12	0.024
Feed intake g/bird	2700.00^{b}	2833.33^{a}	2694.44^{b}	5.69	0.031
Body weight gain g/bird	1133.33^{a}	956.00^{b}	1095.50^{a}	21.78	0.016
Feed:gain	2.38^{b}	2.96^{a}	2.46^{ab}	0.28	0.001

$^{a\text{-}c}$Means in the same column with different superscripts differ significantly (P<0.05). T1: Control diets (corn-soybean based); T2: 25% FSBCM + 0% Fullzyme; T3: 25% FSBCM + 50g/kg Fullzyme.

The impact of multienzyme supplementation to turkey birds fed SBCM based diet is displayed in Table 4. The result indicates that all cost variables evaluated were significantly (P<0.05) affected by Fullzyme supplementation except operational cost and price/kg live weight. Birds fed control diets exhibited higher (P<0.05) mean values on cost/kg gain, followed by those fed T2 diet while those fed T3 diet recorded lower (P<0.05) cost/kg gain. Cost/kg feed, cost of feed consumed, cost of production and feed cost were significantly higher (P<0.05) in birds on control diet compared to those fed SBCM based diets with or without enzyme complex supplementation.

The observed reduction in these cost variables in turkey growers fed FSBCM based diets with or without Fullzyme supplementation may probably be attributed to lower cost per unit of SBCM compared to that of maize. Nevertheless, Fullzyme supplementation significantly reduced cost per kg weight gain of the birds due to improved efficiency of feed utilization. In accordance with the present findings, similar results have been previously reported by Onu *et al*. (2011) and Oguntoye *et al*. (2018). According to Wealleans *et al.*, (2018) and Oladipo *et al.* (2019), the synergetic ability of supplemental enzymes cocktail and probiotic mixture to increase nutrient digestion and bioavailability could also be implicated in the reduction of feed cost per kg gain observed in the present study. The observation of lower cost of production in turkey growers offered FSBCM based diets with Fullzyme supplementation over the control group portray more profit margin. This could be attributed to reduced cost of diet per kg and improved feed efficiency in the birds fed Fullzyme supplemented FSBCM diets. The revenue generated per bird was significantly (P<0.05) higher in the groups that received control and Fullzyme supplemented SBCM diet compared to those fed SBCM diet. Thus, the increased revenue observed in turkeys fed SBCM diet with Fullzyme supplementation over those without Fullzyme might be attributed to improved feed conversion efficiency and utilization that resulted to the increased weight gains of the birds due to synergistic action of multienzymes and probiotics (Oladipo *et al*., 2019; Catootjle *et al*., 2020; Luo *et al*., 2022).

Table 4: Economy of production of turkey growers fed fermented shea butter cake meal (FSBCM) based diet with supplemental enzymes cocktail and probiotic mixture (Fullzyme)

Cost indices	T1	T2	T3	SEM	P-values
Cost/kg feed (₦/bird)	171.67^{a}	116.07^{b}	124.69^{b}	5.02	0.008
Cost/kg gain (₦/bird)	408.57^{a}	328.83^{b}	306.74^{c}	19.59	0.042
Cost of feed consumed (₦/bird)	463.51^{a}	325.00^{b}	335.92^{b}	26.12	0.027
Operational cost (₦/bird)	110.00	110.00	110.00	ND	ND
Cost of production (₦/bird)	573.51^{a}	435.00^{b}	445.92^{b}	6.12	0.006
Feed cost (%)	80.82^{a}	74.71^{b}	75.33^{b}	0.33	0.001
Price/kg live weight (₦/bird)	1500.00	1500.00	1500.00	ND	ND
Revenue (₦/bird)	3645.00^{a}	3429.00^{b}	3592.50^{a}	28.25	0.018

$^{a\text{-}c}$Means in the same column with different superscripts differ significantly (P<0.05). T1: Control diets (corn-soybean based); T2: 25% FSBCM + 0% Fullzyme; T3: 25% FSBCM + 50g/kg Fullzyme. *ND: Not determined

CONCLUSION

The current results demonstrated that the inclusion of 50g/kg Fullzyme® has the potential to enhance the growth performance and reduced cost per kilogram weight gain as well as cost of production of turkey growers fed diets containing FSBCM replacing maize at 25%.

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Soil Chemical Properties Response to Regular Application of Agrochemicals in Ifite-Ogwari, Anambra State, Nigeria

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K E Y W O R D S

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A B S T R A C T

The study on the soil chemical properties response to regular application of agrochemicals was carried out in rice farms at Ifite-Ogwari. Soil samples were taken from rice field that receives various forms of agrochemical and that of adjacent field as control using random sampling techniques at depths of 0-15cm and 15-30cm in three replicates. Sampled soils were air dried, sieved and analyzed in the laboratory using standard routine procedures. Heavy metals As and Pb were analyzed in the laboratory using double acid method. The rest showed that pH was strongly acidic both at soils with applied agrochemicals (rice field) and control, 5.41 and 5.12 respectively. The control also recorded high organic carbon (1.90%), while soil with applied agrochemicals (rice field) had the lowest organic carbon (1.01%); so also, was total nitrogen. Calcium content was low ranging from 2.27 to 4.80Cmolkg^{-1}; magnesium content was moderate ranging from 1.20 to 2.27Cmolkg^{-1}; potassium was very low ranging from 0.14 to 0.19Cmolkg^{-1}; sodium was also very low ranging 0.09 to 0.15Cmolkg^{-1}. Available phosphorus showed low to medium, 3.63mg/kg and 10.4mg/kg respectively. Heavy metals studied also showed that arsenic (As) content which was between 0.01 to 0.16mgkg^{-1} and lead (Pb) 0.13 to 0.22mgkg^{-1} didn't reach the permissible limit given by FAO. The study showed that calcium, available phosphorus, soil pH and arsenic concentration responded significantly to the regular use of agrochemicals in the rice farm.

INTRODUCTION

Agrochemicals are chemicals used in agricultural activities to eradicate weeds, reduce pests and boost soil nutrients (Whitson *et al*., 1999). Herbicides for weed control, pesticides for pest control and, inorganic fertilizers for boosting soil nutrients. Soil which is a recipient to all these agrochemicals acts as filter; buffer, and naturally degrade potential pollutants with the help of soil organic carbon (Burauel and Bassman, 2005), it is also a known fact that the soil is a potential pathway of pesticide transport to contaminate water, air, plants, food and ultimately to human through runoff and sub-surface drainage, interflow and leaching; and the transfer of mineral nutrients and pesticides from soils into the plants and animals that constitute the human food chain (Abrahams, 2002). Inappropriate use of chemical fertilizers and pesticides by farmers can contribute significantly to the soil degradation process. There is evidence that prolonged use of heavy doses ammonium based fertilizers can result in soils becoming more acidic that has serious implications in terms of long-term productivity of soils. One of the environmental risks in using agrochemicals especially, when it is excessively used is the accumulation of various heavy metals in the soil leading to serious consequences (Okafor and Chidozie, 2016). Thus, pollution of heavy metals poses a threat to a country's food production. Some fertilizers and pesticides are known to contain various levels of heavy metals, including Cr and Cu (Kabata-Pendias and Pandias, 1992). Once in the soil, heavy metals are adsorbed - by initial fast reactions (minutes, hours), followed by slow adsorption reactions (days, years) and are redistributed into different chemical forms with varying bioavailability, mobility, and toxicity (Shiowatana *et al.,* 2001; Buekers, 2007). These metals are extremely persistent in the environment, non-biodegradable, non-thermo-degradable and thus readily accumulate to toxic levels. Since they do not break down, they might affect the biosphere for a long time, which is why they are the most dangerous substances in the environment due to their high level of durability and toxicity to the biota (Alkorta *et al.,* 2004). Most rural farmers have long depended on herbicides, pesticides and inorganic fertilizers in growing their crops especially rice, these chemicals often time are judiciously applied, thus tend to constitute environmental hazard. The objective of this study therefore was to ascertain the response of regular use of agrochemicals on soil chemical properties and on selected heavy metals.

Materials and method

The study area

The study was carried out at Ifite-Ogwari, Anambra state which lies between latitude 6° 14' 28" N longitude 7° 6' 46" E and latitude 6° 14' 51" N longitude 7° 6' 47" E. the area falls within tropical savanna, dominated by grasses and sparsely distributed trees. The area experiences two major seasons – rainy or wet (usually starting in March and ends in October) and harmattan or dry season which usually begins in November and last till February (Ejikeme *et al*., 2017). The temperature pattern of the area has mean daily and annual temperatures as 28°C and 27°C respectively. "The mean daily temperature can rise to about 32°C during hot periods of the year usually in the month of February (Ejikeme *et al*.,2017). Humidity is relatively high between 65-80% throughout the year, with average rainfall between 1520–2020 mm per annum (Madueke *et al*., 2021). The textures of soils of the studied sites are mainly clay loam (Umeakuchukwu and Okafor, 2021). The common crops grown by the farmers in the areas are rice, yam, cassava, okra, melon and maize.

Soil sampling

The study focused on rice field with minimum of four (4) years of regular use of agrochemicals like 2,4-D Amine, butachlor and glyphosate (herbicides); Imidacloprid 17.8% SL (brand name-courage) and Kombat (all pesticides). Random sampling techniques were employed in sampling of the soil. Soils were collected randomly at two depths, 0-15 and 15-30 and replicated thrice in an active rice field; same method was used to sample soils at same depth and replication at a nearby two years fallow farm used for yam production which served as control. The sampled soils were air dried and readied for laboratory analysis.

Soil Analysis

The chemical properties that were analyzed are soil pH, total nitrogen, organic carbon, exchangeable bases, exchangeable acidity, effective cation exchange capacity, percentage base saturation, available phosphorus, arsenic and lead.

Soil pH was estimated using pH meter in ratio of 1:2.5 ratio of soil to water (Tan, 1998). Soil organic carbon was determined by titration method (Walkley and Black, 1934).Total Nitrogen was determined using Kjeidahl digestion method. Exchangeable basic cations (Ca2+, Mg2+, K+ and Na+) were extracted in neutral normal ammonium acetate (1N-NH4OAc); where calcium and magnesium was determined using Atomic Absorption Spectrophotometer, while Potassium and Sodium was determined in flame photometer (Schollenberger and Simon, 1945). Exchangeable acidity (Al3+and H+) was determined titrimetrically (Tan, 1998). Base saturation was calculated on percentage basis,

$$\%\mathrm{BS} = \frac{\text{Total Exch.Basis} \times 100}{\text{ECEC}} \qquad (1)$$

Effective cation exchange capacity was determined by summation of Exchangeable bases and Exchangeable acidity. Available phosphorus was determined by Bray (I) method (Bray and Kurtz, 1945).

Data Analysis

Data collected were subjected to two-way analysis of variance (ANOVA) to determine the variation between soil under agrochemical cultivation and control on the parameters studied. The significant difference on the properties studied was determined using Least significant difference (LSD) at 5% probability ($p \leq 0.05$). The data package used was Excel 2010.

RESULTS AND DISCUSSION

The selected chemical properties of the studied soils are shown in Table 1. Figure 1 and 2 showed the selected heavy metals (Arsenic and lead) studied. Table 1 showed mean values of selected chemical properties. pH across the tested soils were strongly acidic to moderately acidic (FAO, 2004), with pH values ranging from 5.12 to 5.41, control and soil that had agrochemicals respectively. Pesticides and herbicides are easily degraded at alkaline soils or soils with high pH (Raeder *et al*., 2015; Schilder, 2008), the moderate acidic soil (pH 5.41) recorded at STHA could be encouraging persistence of pesticides and herbicides in the soil. Organic carbon was high at the control having 1.90% and moderate at rice field (soils that had agrochemicals) which has 1.01%, which is in tandem with Baboo *et al*., (2013); even though there was no significant difference between the control and the STHA. Total nitrogen showed a range of 0.09% to 0.16% with the control recording the highest and the soils that had agrochemicals (STHA) recording the lowest; although there was no significant difference on total nitrogen between control and STHA, but the 56% decrease in Total nitrogen at STHA was in consonant with (Damin and Trivelin, 2014) . Calcium was generally low, with control recording 4.80cmolkg^{-1} while soils that had agrochemicals recorded 2.27cmolkg^{-1}, which was contrary to Bulu *et al*., (2019); calcium showed significant difference at 0-15cm depth between soils that had agrochemicals and control. Potassium was very low with a range of 0.14 to 0.19cmolkg^{-1}.

Sodium on the hand was also very low with control recording 0.15cmolkg^{-1} and soils that had agrochemicals showing 0.14cmolkg^{-1}. Available phosphorus was low to medium and showed significant difference at 0-15cm depth, with the control recording more available phosphorus 10.4mgkg^{-1} over soils that had agrochemicals which had 3.39mgkg^{-1} which was contrary to Ghosh *et al*., (2014), where insecticides, fungicides and pesticides caused significant enhancement in the level of available phosphorus. Figure 1 and 2 showed the effect of agrochemicals on arsenic and lead concentration levels respectively.

Table 1. Mean chemical properties of studied soil

Treatment	Soil depth (cm)	pH	Org. Carbon (%)	Tot.N (%)	Al3+	H+	Ca2+	Mg2+ (Cmol/kg)	K+	Na+	ECEC	BS (%)	Av.P (mg/kg)
STHA	0-15	5.41	1.11	0.09	1	0.23	2.27	1.2	0.14	0.09	4.93	75.5	3.63
	15-30	5.35	1.01	0.09	0.73	0.33	2.67	1.47	0.19	0.13	5.52	81.1	3.39
Control	0-15	5.12	1.9	0.16	1.33	0.47	4.8	2.27	0.16	0.14	8.95	81.7	10.4
	15-30	5.23	1.55	0.13	0.7	0.33	3.33	2.03	0.16	0.15	6.74	83.3	6.23
LSD ($p \leq 0.05$)		*	NS	NS	NS	NS	*	NS	NS	NS	NS	NS	*

Al^{3+}= Aluminium, Tot. N = Total nitrogen, H^{+} = hydrogen, Ca = Calcium, Mg = magnesium, K = potassium, Na = sodium, BS = Base saturation, ECEC = effective cation exchange capacity, Av.P = Available phosphorus, STHA = soils that had agrochemicals (rice field), * = significant difference, NS = not significant difference.

In figure 1, soils that had agrochemicals (STHA) showed almost the same arsenic (As) content 0.16mgkg^{-1}, and 0.01 to 0.02mgkg^{-1} for the control. However, there were significant different of arsenic content between soils that had agrochemicals (STHA) and control at 15-30cm depth, the concentration however, was below the (FAO/WHO) permissible limit of 1-30mg/kg.

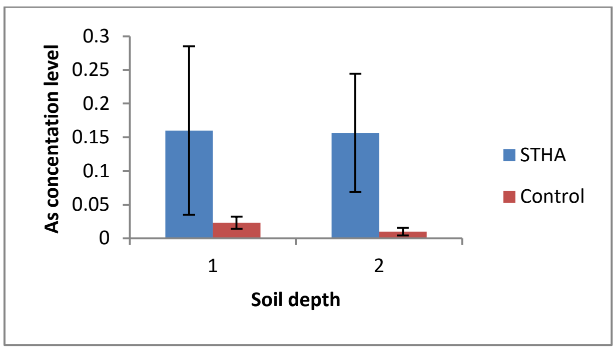

Figure 1. Arsenic content of STHA and Control at different depth (1 = 0-15cm, 2 = 15-30cm)

In figure 2, Lead (Pb) recorded highest value 0.22mgkg^{-1} at 0-15cm depth in STHA and lowest 0.13mgkg^{-1} at 0-15cm depth in control. However, there was no significant difference of lead (Pb) content between STHA and control. The concentration levels at the soil that had agrochemical and control were drastically below the (FAO/WHO) permissible limit.

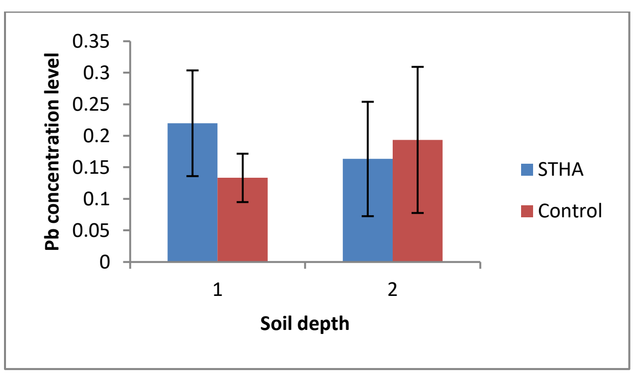

Figure 2. Lead (Pb) content of STHA and Control at different depth (1 = 0-15cm, 2 =15-30cm)

CONCLUSION

The soils were strongly to moderately acidic and showed significant difference between soils that had agrochmeicals and control, which could mean that agrochemicals that were applied in the soil have effect on soil pH. Percentage organic carbon was high at the control in comparison with STHA but has no significant difference on the studied soils. Calcium was generally low but showed significant difference. Potassium and sodium was very low, all showing no significant difference on the studied soil. Available phosphorus maintained high level at the control over soils that had agrochemicals and showed significant difference only at 0-15cm depth. The values of the heavy metals studied did not reach the FAO permissible limits in the soil (0.3mgkg^{-1} and 1-30mgkg^{-1}) for Pb and As respectively, however, the significant difference shown by arsenic content could be that the agrochemicals applied in the soil increases arsenic content.

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SUB-THEME 6

APPLYING ECONOMICS AND EXTENSION PRINCIPLES AND POLICIES TO NATURE CONSERVATION, SUSTAINABLE AGRICULTURE AND CLIMATE CHANGE RESPONSE

Determinants of Factors Influencing the level of Mitigation of Heat Stress on Broiler in Oyo State

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K E Y W O R D S

Broiler
Determinants,
Mitigation level,
Perceived heat stress,

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A B S T R A C T

Compared to developed nations, Nigeria has a gap in its protein consumption. Poultry production being seen as a way out of this problem is faced with climate change challenges. Smallholder broiler farmers were the most vulnerable due to low copping infrastructural capacity. This study, therefore, investigated the determinants of factors influencing the level of mitigation of heat stress (HS) on broiler by farmers in Oyo state. The study employed a systematic sampling technique using registered members of the Poultry Association of Nigeria. Structured questionnaire was used to collect data: demographic, socioeconomic profile, institutional factors, perceived heat stress and coping methods. Data were analyzed using descriptive statistics and multinomial logit regression α=0.05. The study revealed that majority (76.7%) were male, mean age=48years. The average years of education and rearing experience were 12 and 6 years respectively. Majority (71.67%) accessed extension/vet doctor services, while only (23.3%) accessed credit. Temperature was perceived to be highest in January-March, while extremely cold weather was perceived in August. The symptoms of HS identified were gasping, wing raising, docility, reduction in feed, increased water intake, panting, weight loss, slow growth rate, pest and disease infestation, vaccine failure and increase mortality. Multinomial logit result showed all the independent variables to positively influence the level of farmers' mitigation except sex and household size. Age, sex, access to credit and farmers' income, household size, education, rearing experience, labour used and stock size were significant at 1% and 5%. Access to credit and training were recommended

INTRODUCTION

The current global population is 7.6 billion. With about 83 million people being added to the world's population yearly, it is expected to be 8.5 billion by 2030, 9.7 billion in 2050 and 10.4 billion in 2100, (United Nations Department of Economic and Social Affairs, Population Division, 2022). It implies that seventy percent increase in food production is required between now and 2050 for food production to keep pace with the growing world population (Watt Executive Guide, 2012;2016). Presently, Nigeria has a gap in its protein consumption in comparison with other global economies (Nigerian Protein Deficiency Report, 2020 as cited in Daily Trust, 2021). By the year 2050 this problem would have escalated if adequate measures are not put in place. Poultry production is seen as the way out of this problem. Poultry contributed about 30% of animal proteins consumed globally (AGRA, 2014). Global poultry population is estimated to be about 16.2 billion, out of this 71.6% were in developing countries, producing 67, 718,544 metric tons of chicken meat and 57,861,747 metric tons of hen eggs (Hundie, *et al*.,2019). The poultry industry contributes significantly to the Nigeria's economy. It provides employment opportunities, income for the populace and serves as a source of high quality protein. It equally contributes to food security and poverty alleviation (Nasiru *et al.*, 2012).

Despite, the contribution of poultry to food security, poverty alleviation and economic growth, the industry is cumbered with numerous constraints which include climate among others. (Adeyonu, *et al*.,, 2021). Climate change has affected poultry production by imposing stress on the homeostasis in the birds due to extreme climatic situations: high temperature, flood or drought, and water scarcity (Tiruneh and Tegene, 2018). These conditions result in production losses (reduction in growth rate, decrease in number of egg a hen lay, increased morbidity and mortality (Henry, *et al*. 2012; Irivboje, *et al.*, 2021*)*. Poultry birds has adaptive capacity to temperature increase, but the coping mechanisms subject the birds to losses and diversion of nutrients for production to thermoregulation (Irivboje, *et al*., 2021*)*. During, hot weather, feed consumption is reduced so as to reduce metabolic heat production.

Systemic nutrients are utilized for heat loss mechanisms instead of using it profitably for muscle accretion. Digesta mobility in the gastrointestinal tract is greatly reduced and efficiency of nutrient utilization in the intestines is lowered. Histomorphometric assessment revealed that the epithelial cells of the intestines are affected by heat stress (Shittu, *et al*., 2020). Vasodilation of blood vessels at the periphery reduces blood flow across gastrointestinal tract to lower the efficiency of digestion and nutrient utilization which in turn lowered the final live weight and dressing percentage (Okonkwo, and Ahaotu, 2019).

Broiler chickens, as a result of global warming grow so rapidly that muscular development surpasses bone development leading to metabolic bone disorder (Shields and Orme-Evans, 2015). The consequence of this is Sudden Death Syndrome manifesting by sudden convulsions and wing-beating, and birds lie on their backs (Julian, 2005). ICAR (2010) Network Project on Climate Change noted that, as environmental temperature ≥ 34°C is reached broilers mortality due to heat stress increases by (8.4%) as compared to layers (0.84%). The burden of heat stress commonly experienced in the tropical areas of Africa will be aggravated by climate change going by the predicted global temperature surge of between 3^{oC} and 6^{o} C (ICAR- Directorate of Poultry Research, 2020). Rainfall and wind that give relief to heat stressed birds are now scarcely experienced.

Under this scenario, the feeding strategy, housing and other management practices being used presently have to be modified for farmers to be less vulnerable to this adverse conditions. The selection strategy for both layer and broilers has to be reoriented to come up with heat tolerant varieties. Genes responsible for conferring better adaptability may be introgressed into the high performing low adaptive varieties through traditional as well as molecular breeding tools (ICAR- Directorate of Poultry Research, 2020)

Adaptations are adjustment to interventions or shock, which is done to manage the losses or take advantage of the opportunities that is presented by a changing climate (IPCC, 2013).

The main goal of mitigation is to increase the capacity of the system to survive external shocks/changes. With the foregoing, the study therefore, has these specific objectives:

(i) profile the perception of farmer to temperate change; and (ii) determine the factors that influence the level of mitigation against heat stress.

METHODOLOGY

Types and Sources of Data

This study was carried out in Oyo States, Nigeria. The study employed primary data. The data collected include the demographic: gender, age, marital status, level of education, household size, rearing experience, primary occupation and socioeconomic profile: access to credit, income, access to extension, rearing system, stock size, mortality rate of the respondents, perceived heat stress data and coping methods adopted. Institutional factors include access to extension services, access to credit

Sampling Techniques and Sample size

Oyo States was the purposive selection out of the six states in southwest Nigeria; based on the highest poultry population distribution in the state, (Federal Department of Livestock, 2010). The study employed a systematic sampling technique based on available records of registered members of the Poultry Association of Nigeria (PAN). The systematic sampling technique enables the probability that any member of the Poultry Association of Nigeria to be selected. This sampling method is an equal probability selection method. It is used to easily identify suitable sampling frame (CASRO, 2011). It has the disadvantages of difficulties in determining the precision of estimates and for large data sets it tend to be time consuming to process. Systemic sampling technique is a non-random sampling technique in which the first member of the sample is pre-selected by random sampling method. Thereafter selection is as kth item on the list where k is a positive integer such that $k = \frac{N}{n}$ where N= total population and n= total number of sample size.. A well-structured questionnaire was used to elicit data from the broiler farmers. The total number of respondent broiler farmers selected were 120

Analytical Framework

Descriptive Statistics

Demographic, socioeconomics characteristics and perceived effects of climate change and adaptation strategies, were captured using, percentages, mean, graphs and frequency Climate Change Adaptive Index

Climate Change Adaptive Level Index for the broiler farmers was constructed so as to classify the farmers into different classes of adaptation levels. This was based on the number of actionable mitigation steps against the climate changes factors that take yes=1 and no=0 answers in the questionnaire. The maximum number of actionable steps allowed to state in the questionnaire were eight: planting trees around the poultry houses, installation of mist blowers, reformulate the diet, giving of chilled water to birds, reduce stock density per meter square, provide enough ventilation, repeat vaccination, improved droppings management. A farmer who did not take any action get score of zero, if 1 action was taken the farmer get a score of 1, 2 actions get a score of 2 up to score of 8. Composite score was then used to classify farmers to different adaptive level: high, intermediate and low; the categorization is done based on, High level: Between 5 points to mean standard plus deviation, Intermediate level: Between upper and lower categories, Low level: Between mean minus standard deviation point to zero

Multinomial Regression

Logistic regression can be extended to handle polytomous responses when the dependent variables (Yi) is taking i >2 categories this is refer to as multinomial regression.

, El-Habil (2012). Multinomial logistic regression applies maximum likelihood estimation in transforming the dependent variable into a logit variable, while changes are calculated in the log odds of the dependent and not in the dependent itself as in the ordinary least square. The multinomial logistic regression adopted from EL-Habil (2012) is defined as:

$$Log\left[\frac{\pi_j\,(X_i)}{\pi_i\,(X_i)}\right] = \alpha_{oi} + \beta_{1j}X_{1i} + \beta_{2j}X_{2i} + \cdots \beta_{pj}X_{pi} \quad (1)$$

Where $j = 1, 2, \ldots (k-1)$, $i = 1, 2, \ldots, n$

Where all the π*'s* adds to unity, then the reduced model is:

$$Log(\pi_j\,(X_i) = \frac{exp^{\alpha_{oi} + \beta_{1j}X_{1i} + \beta_{2j}X_{2i} + \cdots \beta_{pj}X_{pi}}}{\sum_{j=1}^{k-1} exp^{\alpha_{oi} + \beta_{1j}X_{1i} + \beta_{2j}X_{2i} + \cdots \beta_{pj}X_{pi}}} \quad (2)$$

Where π is the response categories or level of mitigation strategies adopted by broiler farmers, Xi are the vector(s) of explanatory variables (demographic: gender, age, marital status, level of education, household, size, rearing experience and socioeconomic characteristics: access to credit, access to extension, stock size, mortality rate), βj is the parameter to be estimated which uses maximum likelihood, estimate method (Chatterjee and Hadi, 2006).

Multinomial logistic regression uses a baseline category and the predicted probability of estimate is defined as:

$$\pi_j = \frac{e^{\alpha_j + \beta_j Y}}{\sum_h e^{\alpha_h + \beta_h Y}} \quad (3)$$

The first or last endogenous products are often used as the baseline sample, the probability of each socioeconomics and demographic characteristics is predicted from:

$$\widehat{\pi_1} = \frac{exp(y_i)}{1 + \sum exp(y_i)} \quad (4)$$

Where y_i is the predicted responses from the multinomial coefficient. The multinomial logistic regression model is simply defined as:

$$Log(\pi_i\,(X_i)) = \alpha_{oi} + \alpha_{1j}X_{1i} + \alpha_{2j}X_{2i} + \cdots \alpha_{pj}X_{pi}$$

Where: π is the response categories or level of mitigation strategies adopted by broiler farmers

α_i = parameter to be estimated

X_i = vectors of socioeconomics and demographic characteristics.).

The explanatory variables are as follows: X_1 = Age of broiler farmer (years), X_2 = Sex of broiler farmer (dummy variable, 1 = male; 0 =female), X_3 = Household size, X_4 = Marital status of broiler farmer (married = 1; single, divorced or widowed = 0), X_5 = Educational level of household of broiler farmer in years , X_6 = Extension Access to credit 1if Yes; 0 otherwise , X_7 = Experience, X_8 = labour for broiler production, $X_{9=}$ stock size, X_{10} =Access to credit (dummy variable, 1 = access; otherwise =0), X_{11} = Income

RESULTS AND DISCUSSION

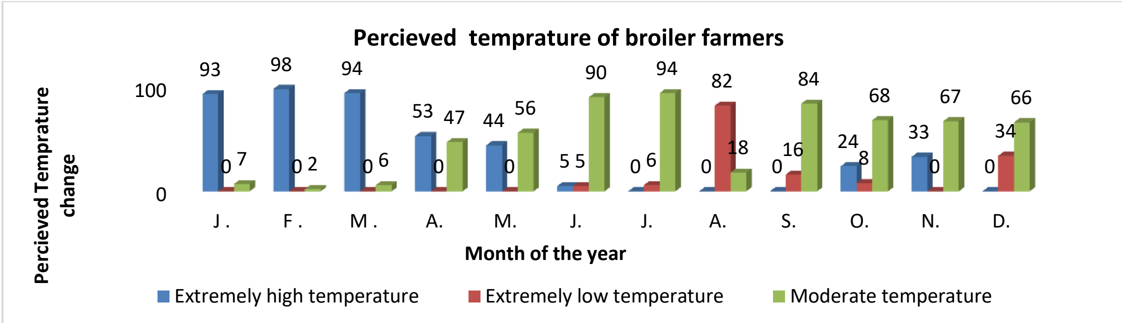

Fig. 1: Monthly perceived temperature changes of broiler farmers
Author's computation, 2023

Table 3: Determinants of factors influencing the level of mitigation against heat stress

Variables	coefficient	P>Z
Age	0.036	0.000
Sex	-0.382	-0.000
Household size	-0.041	-0.002
Marital status	2.008	0.215
Education	0.055	0.005
Extension	0.03	0.011
Experience	0.010	0.004
labour	0.800	0.002
Scale	1.91	0.008
Access to credit	7.74e08	0.000
Income	9.11e08	0.000
cons	11.98	
observations	120	
LRChi^2	164.82	
Prob b>Chi	0.0000	
R^2	0.53473	
Log likelihood	-160.9062	

Author's computation, 2023

Determinants of factors influencing the level of mitigation against heat stress

The level of farmers' adoption of mitigation strategies was estimated using multinomial logit model(MNL). MNL was estimated by normalizing one category referred to as the base category. The parameter estimates provided only the direction of the effect the independent variables in the dependent variables and do not represent the actual magnitude of change of probabilities. Thus, the marginal effects of the MNL, which measure the expected change of a particular level with respect to a unit change in an independent variable, are reported and explained. The table presents the marginal effects along with the level of significance. The MNL diagnostic statistics revealed the log likelihood as -160.9062 with p value of 0.0000. pseudo R^2 of 0.535 and log likelihood Chi^2 164.82. This implies that the model as a whole significantly and jointly predicted the level of mitigation of broiler farmers against heat stress in the study area.

The results on the table show all the independent variables to positively influence the level of farmers' mitigation against heat stress except sex and household size. Age, sex, access to credit and farmers' income were significant at 1% level of significance, while, household size, education, rearing experience, labour used and stock size were significant at 5% level of significant.

CONCLUSION

In conclusion heat stress is a serious issue in the study area. It is perceived to be sever in the month of January to march, but began to subside from the month of April. The short term symptoms of heat stress in broiler were identified to be gasping, wing raising, docile birds, reduction in feed intake, increase water intake and panting while, long term symptoms of heat stress in broiler were weight loss, slow growth rate, pest and disease infestation, vaccine failure, and increased mortality. Age, access to credit and farmers' income, education, rearing experience, labour used and stock size were significant factors that positively influence the level of farmers' mitigation against heat stress.

RECOMMENDATIONS

Therefore, this study recommends:

i. Rearing experience and education improved the level of farmers' mitigation against heat stress., therefore, farmers should be trained periodically to increase their awareness to mitigation strategies and there be encouraged to improve the mitigation level to heat stress.

ii. Access to credit and farmers' income improved the level of farmers' mitigation against heat stress in broiler, therefore, government and stockholders in the business should make credit accessible to farmers and farmers are encouraged to join cooperative group to be able to access credit.

iii. labour used and stock size improved the level of farmers' mitigation against heat stress in broiler, therefore, factors that keeps the farmers operating at the smallholder level: adequate credit, small market share and electricity problem that discourage storage of products should be addressed.

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Perceived Effect of COVID-19 Pandemic on Rural Farming Households in Nigeria

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K E Y W O R D S

Agriculture
COVID-19 Pandemic,
Food security,
Households,
Government,
Rural farming

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A B S T R A C T

The COVID-19 breakout in the world prompted the Nigeria government to enforce a lockdown measure at the end of March which came as a shock to small-scale farmers as movement restrictions were implemented by security operatives across the country which prevented many farmers to gain access to their fields. Some experts opined that the lockdown situation culminated in low food production, enmeshed within other COVID-19 crises like loss of livelihoods, high food prices among other issues.

The study employed descriptive statistics and the result showed that the farmers were aware of the COVID-19 pandemic. This restriction on movement of human and goods resulted to farmers loss of their means of livelihood and also reduced their purchasing power (money) thereby making them more vulnerable to food insecurity. As showed in the result, the monthly farm income, farm produce sold decreased during the pandemic while the cost of farm inputs (labor, fertilizer, herbicide and transportation) increased during the pandemic. From the result above, the COVID-19 pandemic drastically reduced the purchasing power of the farming households and access to nutritious food became difficult.The study therefore recommend that government and relevant organizations should support rural farmers to build their disaster resilient against future disaster. And also, to provide support or grants to rural farmers as to minimize the shock as a result of the COVID-19 pandemic and also to cushion the effect of the virus outbreak on rural farming households.

INTRODUCTION

The COVID-19 breakout in the world and in Africa with the lockdown measures taken by government across the Sub-Saharan Africa (SSA) to curb the spread of the virus interrupted the farming activities across Africa. Already before the COVID-19 pandemic breakout in Africa, Africa continent was faced with numerous challenges that posed a threat to the attainment of the SDG 2 (Zero hunger) by 2030 (Aromolaran *et al*. 2020; Oseni *et al*. 2020). The outbreak of the covid-19 pandemic worsened the situation as it left most of the smallholder farmers without means of livelihood among other losses. Effects of the COVID-19 and the associated measures put in place by government of Nigeria to curb the spread as reported by literatures included: decline in food consumption and income (Aromolaran *et al*. 2020; Oseni *et al*. 2020), increased food insecurity (UNDP, 2020), panic buying and sharp price spikes (Oyekanmi, 2020; PWC, 2020; FAO, 2021a; Obot *et al*. 2022a; Obot *et al*. 2022b), migration, displacement (IOM, 2020) and remittances (Anaeto, 2020; Andam *et al*. 2020a).

For instance, Andam *et al*. (2020b) reported that about 33% of households in Nigeria lost their income during the COVID-19 pandemic. Also, World Food Programme (WFP, 2020b) estimated that 270 million people in 83 countries where it operates faced severely food-insecure at the end of 2020, which represents about 82% increase prior to the emergence of the pandemic. According to FAO (2021b), the COVID-19 pandemic has exacerbated the already severe food security situation in several states in Nigeria.

This had some effects on small-scale farmers as many farmers access to their farms and markets were restricted and since most small-scale farmers do not have storage facilities, they incurred a lot of postharvest losses forcing some to sell their produce at very cheap prices (SWOFON, 2020).

The FAO suggested that support for agricultural production (e.g., seeds distribution) to small-scale farmers was essential to reduce the impact of the post-COVID-19 pandemic on the already vulnerable households in Sub-Saharan Africa (FAO, 2020).

The study contributed to the understanding of the actual extent of the effects of COVID-19 on smallholder farm households and provide useful evidence for better policy decisions.

The specific objectives of the study were to: (1) Describe the socio-economic characteristics of the rural farmers (2) examine the knowledge of rural farmers on COVID-19 pandemic and, (3) determine the effect of the COVI-19 pandemic on the economics of farming households.

METHODOLOGY

Study area

The study area is the Federal Republic of Nigeria. Nigeria has a population of 166.6 million people (UNDESA, 2011) with a total area of 923,800 sq km and occupies about 14 per cent of land area in West Africa. The country lies between 4^{o}N and 14^{o}N, and between 3^{o}E and 15^{o}E. Nigeria is located within the tropics and therefore experiences high temperatures throughout the year. The mean for the country is 27^{o}C. Average maximum temperatures vary from 32^{o}C along the coast to 41^{o}C in the far north, while mean minimum figures range from 21^{o}C in the coast to under 13^{o}C in the north.

The study locations and households were selected from four States in Nigeria (Akwa Ibom, Anambra, Enugu and Delta State).

Data Collection and Analysis

The primary data for the study was obtained through structured questionnaire. A purposive and simple random sampling procedure was used in the selection of the four States and the respondents for the study.

The scientific formula to calculate the sample size for the household survey is proposed by (Rose *et al*., 2014). They assert that to calculate the sample size based on the sample required to estimate a proportion with an 95% confidence level; you can use the following formula:

$$N_r = \frac{4pq}{d^2}$$

Where Nr = required sample size, p = proportion of the population having the characteristic, q = 1-p and d = the degree of precision.

The proportion of the population (p) may be known from prior research or other sources; if it is unknown, use p = 0.5, which assumes maximum heterogeneity (i.e., a 50/50 split).

The degree of precision (d) is the acceptable margin of error. According to (Krejcie and Morgan, 1970 and also cited by Taherdoost, 2017), the general rule for science research is that a 5% margin of error is acceptable for categorical data and 3% is acceptable for continuous data. Setting d = 0.05, which is 5%, is crucial since some high level of categorical data would be collected.

Therefore, the sample size N_r is calculated mathematically as:

$$N_r = \frac{4 \times 0.5 \times (1 - 0.5)}{(0.05)^2}$$

$$N_r = 400$$

The first stage was the selection of four States out of the thirty-six States and the FCT that make up Nigeria which was done purposively. The second stage of sampling was the random selection of one hundred (100) farming households from each of these States to give a total of 400 respondents for the study. This survey was a cross-sectional study conducted using a structured questionnaire. The questions focused on the period before the COVID-19 outbreak and during the pandemic. The questionnaires were administered by trained field officers who visited each of the participants in their respective households.

Descriptive statistics (means, frequency distribution, percentages) was used to analyze the data collected.

RESULTS AND DISCUSSION

Socioeconomic characteristics

Sex: Majority (73.0%) of the farming households were male while the remaining 27.0% were female. The implication is that men were more engaged in farming activities than the female in the study area (Table 1).

Age: Table 1 above showed that majority (82.25%) of the farming household were between the age bracket of 26 – 50 years, while the remaining 13.75% and 4.0% were within the age bracket of 51 – 75 years, and 1 - 25 years respectively. Thus, this implied that the people engaged were actually in their youthful age. The result agreed with Obot *et al*. (2022a) that the people engaged in the farming activities were in their youthful age (Table 1).

Marital status: Majority (90.25%) of the farming households were married, while the remaining 5.25, 3.25% and 1.25% were single, separated/divorced and widow/er respectively.

Level of education: The finding showed that majority (52.5%) of the farming households in the attended secondary school, while the remaining 37.5%, 6.75% and 3.25% attended primary, no formal education and tertiary institution respectively. The implication was that the farming households were literate and as such can easily understand and accept new innovations. This agreed with Obot *et al*. (2022a) that literate farmers can easily adopt new technologies

Farming experience: The study found out that majority (74.5%) of the farming households were in farming for the past ≤ 6 years while the remaining 19.75%, 4.75% and 1.0% were in farming for over 7-12years, 13-18years and, 19 years and above respectively. This implied that the farming households were better experienced in agriculture and the risk involved in it.

Household size: Majority (73.5%) of the farming households in the study area had household size within ≤ 5 persons, while the remaining 26.5 had household size within the bracket of 6 and above.

Farm size: Majority (56.0%) of the farming households had farm size of ≤ 2 hectares, while the remaining 34.0%, and 10.0% had farm size of 3 – 4 hectares and, 5 hectares and above respectively. This agreed with Obot *et al*. (2022a) that farmers in the study area were mostly small holder farmers (Table 1).

Table 1: Distribution of the farming household's socio-economic characteristics

Sn	Variable	Frequency (n = 400)	Percentage (100%)
1	Sex		
	Male	292	73.0
	Female	108	27.0
2	Age (years)		
	1 – 25	16	4.00
	26 – 50	329	82.25
	51 – 75	55	13.75
3	Marital status		
	Single	21	5.25
	Married	361	90.25
	Widow(er)	5	1.25
	Separated/Divorced	13	3.25
4	Level of education		
	No formal education	27	6.75
	Primary	150	37.5
	Secondary	210	52.5
	Tertiary	13	3.25
5	Farming experience (Years)		
	<= 6	298	74.5
	7 – 12	79	19.75
	13 – 18	19	4.75
	19 and above	4	1.0
6	Household size (No)		
	≤ 5	294	73.5
	6 and above	106	26.5
7	Farm size (Ha)		
	≤ 2	224	56.0
	3 – 4	136	34.0
	5 and above	40	10.0

Field survey 2020/2021

Farmers Knowledge and Attitude on COVID-19 Pandemic

Knowledge of the virus: Majority (83.0%) of the small holder farmers were aware of the Covid-19 pandemic while the remaining 17.07% were not aware of the virus. The implication is that majority have knowledge about the existence of the virus.

Where did you first hear about the virus: Majority (75.25%) of the small holder farmers heard about the existence of the virus from relative/friends, while the remaining 17.75%, 4.0% and 3.0% heard about the virus from extension workers, cooperative and social media respectively.

Do you believe the virus exist: The finding shows that majority (85.0%) of the small holder farmers do not believe in the existence of the virus, while the remaining 15.0% believed in the existence of the virus. The result corresponds with Ogubuike *et al*. (2021).

How can one contact the virus: The researcher found out that majority (75.75%) of the small holder farmers did not have idea of ways of contacting the virus, while the remaining 13.25%, and 11.0% had the knowledge that the virus can be contacted by air and coming in contact with infected person. This corresponds with Ogubuike *et al*. (2021) who found that 20% of respondents in their study area were not aware of how COVID-19 spread.

Will those infected die: Majority of the small holder farmers (89.25%) believed that the virus is not deadly while 10.75% believed the virus is deadly.

Do you think you can be infected: Majority (91.3%) believed they cannot be infected while the remaining 8.7% believed they can be infected.

Do you adhere to government measure to prevent the spread of the virus: Majority (67.75%) of the farmers were adherence to government's directive on measure to reduce the spread of the virus while the remaining 32.25% were not adherence to government's directive (Table 2).

Table 2: Knowledge, Attitude and Perception

Sn	Variable	Frequency (n = 400)	Percentage (100%)
1	Knowledge of the virus		
	Aware	332	83.0
	Unaware	68	17.0
2	Where did you first hear about it		
	Extension workers	71	17.75
	Relatives/friends	301	75.25
	Cooperative	108	4.0
	Social media	266	3.0
3	Do not believe the virus exist		
	Yes	60	15.0
	No	340	85.0
4	How can one contact the virus		
	Airborne	53	13.25
	Physical contact with infected person	44	11.0
	No idea	303	75.75
5	Will those infected of the virus die		
	Yes	43	10.75
	No	357	89.25
6	Do you think you can be infected		
	Yes	35	8.7
	No	365	91.3
7	Do you employ any of the measures to prevent contacting the virus		
	Yes	271	67.75
	No	129	32.25

Field survey 2022

Effect of COVID-19 Pandemic on Farming Households

From the result above, there was a drastic drop in the purchasing power of the farmers during the COVID-19 pandemic than before the pandemic. This can be attributed to the fact that government-imposed measures to tackle the spread caused the hike in prices of available farm inputs, loss of farm produce etc.

The monthly farm expenditure decreased from ₦40, 371 before the pandemic to ₦11, 610 during the pandemic. This was in consonance with the SAR *et al*. (2010) that the presence of the pandemic prompted increased in hunger and malnutrition as a result of the restriction of goods in order to curb the spread of the disease.

The monthly health expenditure decreased from ₦17, 926 before the pandemic to ₦3, 079 during the pandemic.

The monthly food expenditure increased from ₦2, 748 before the pandemic to ₦5, 690 during the pandemic as a result of closure of markets and food groceries etc. As such, food became scarce and prices of available food items were hike. This confirmed the FAO (2021) findings that the lockdown limited access to agricultural inputs for major staple crops such as rice, cassava, maize etc.

The cost of farm inputs (farm labor, fertilizer, herbicides and transportation) increased from ₦15, 341. 79, ₦19, 216.05, ₦35, 219.70, ₦1, 688.80 before the pandemic to ₦16, 297.13, ₦48, 569.00, ₦39, 304.28, ₦8, 373.75 during the pandemic. This confirmed the result by Oyetoro *et al*. (2020); Balana *et al*. (2020) that the prices of farm inputs surged as a result of foreign exchange volatility as most of the inputs were imported.

The number of food consumption per day remained almost the same as before the pandemic it stood at 2. 94 and the during the pandemic it reduced a bit to 2.53. This confirmed the result by Zurayk (2020) who observed that the pandemic has a negative impact on all the four fundamental dimensions of food security, as defined by FANTA (2003), which include availability, accessibility, utility, and stability, which will further affect the sustainability of food security in the world.

The quantity of farm produce sold decreased from 49.10 before the pandemic to 48. 93 during the pandemic as a result of restriction of movement of goods, closure of markets and increased in the prices of available goods. This confirmed the result by Egger *et al*. (2021); Miguel *et al*. (2021); that farmers were making a lesser profit due to reduced consumption.

Table 3: Comparison of the effect of COVID-19 on farming households before and during the pandemic

S/N	Well-being indicators	Duration	Mean	Std. Deviation	Std. Error Mean
1	Monthly Farm Income	Before	14881.38	21805.72	1090.29
		During	14427.73	16165.33	808.27
2	Monthly farm expenditure	Before	40371.25	54920.3	2746.02
		During	11610.5	12211.23	610.56
3	Monthly health expenditure	Before	17926.01	45564.67	2278.23
	After	During	3078.97	1844.67	92.23
4	Monthly food expenditure	Before	2748.63	1706.64	85.33
		During	5686.5	5382.38	269.12
5	Cost of farm labor	Before	15341.79	15876.8	793.84
		During	16297.13	21170.78	1058.54
6	Cost of fertilizer	Before	19216.05	34000.07	1700
		During	48569	53238	2661.9
7	Cost of herbicides	Before	35219.7	47791.4	2389.57
		During	39304.28	48470.2	2423.51
8	Number of food consumption per day	Before	2.53	0.7	0.035
		During	2.94	0.66	0.033
9	Cost of transportation per month	Before	1688.8	1445.57	72.28
		During	8373.75	10117.28	505.86
10	Quantity of farm produce sold	Before	49.1	23.23	1.162
		During	48.93	25.82	1.291

Field survey (2022)

CONCLUSION

This study investigated the effect of COVID-19 pandemic on rural farming households in selected states in Nigeria. As it is defined that food security is a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life. From the result above, the COVID-19 pandemic drastically reduced the purchasing power of the farming households and access to nutritious food became difficult thereby exposing the farmers to food insecurity. However, there was also increased in farm inputs during the pandemic which made it difficult for farmers to have savings.

The study therefore recommend that government and relevant organizations should support rural farmers to build their disaster resilient against future disaster. And also, to provide support or grants to rural farmers as to minimize the shock as a result of the COVID-19 pandemic and also to cushion the effect of the virus outbreak on rural farming households.

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Analysis of Value Addition of Cassava Products in Nasarawa State, Nigeria

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ABSTRACT

The study examined cassava products value addition in Nasarawa state, Nigeria. Data were collected from 1,360 respondents and analysed using general linear model statistics. The result showed that boiled cassava root, cassava bread, cassava chips, cassava flakes, garri, High Quality Cassava Flour (HQCF) and meat pie had mean incomes of N555.00, N3,429.17, N225.00, 642.86, N3,642.86, N119.00, 127.66, N121, 288.37 and N1,490.00, respectively. The mean incomes from cassava chips, HQCF, and garri were significantly (p<0.05) higher than mean incomes of the backed Cassava products (Cassava flakes, meat pie, Cassava bread and boiled Cassava roots). Also, the mean income differential of cassava flakes, garri, HQCF and meat pie were significant at P<0.05. Processors that produce only boiled cassava roots, cassava bread, chips, flakes, garri, HQCF and meat pie (level 1) had mean incomes of N555, N3, 429.17 N 196,666.67, N3, 642. 86. N 172,319.15 N 108, 683.72 and N 1, 490, respectively. Those of them that processed cassava roots into cassava chips and HQCF or garri (level 2) recorded mean income of N 147,102.33 and those that processed cassava roots into cassava chips, garri and HQCF (level 3) settled with mean income of N 222,441.86. Comparatively, mean income of level 1 is significantly (P<0.05) lower than the mean incomes of levels 2 and 3 (with differences of N 58018.89 and N 98,955.89). However, the mean income differential between levels 2 and 3 is not significantly different. Processors should concentrate on processing chips, garri and or HQCF for better economic gain.

INTRODUCTION

With increasing globalization of agro-food systems and liberation of developing countries' economics, rural communities are facing great challenge to secure and improve their livelihood (Leo and Chukwu, 2015). The capacity of the small farmers according to Umeh (2013) to market their agricultural products is one of the major challenges as liberation generates a competitive environment not only for products but also food crops supplying major urban centres within. The confrontation of agro-food products locally produced with similar products produced and processed abroad with more advanced technologies and the related capacity of consumers and end-users to select their procurement from different sources give more emphasis on product organoleptic and sanitary attributes; norms, traceability, freshness, all becoming key elements of the competitiveness of competing agro-food systems (Abba, 2009). Many rural households, the poorest, are not able to benefit from new market opportunities or to maintain their position in the market exchange and therefore marginalized.

Approximately 70 percent of cassava processing occurs at small and medium size centers near villages. In 2012, there were 75,000 total small and medium processing centers that employed roughly 3 million people—most of which were small scale and generated less than 5 tonnes of high-quality cassava flour per day. Medium and large-scale processors struggle to stay afloat due to high transportation costs, mainly due to the poor condition of rural Nigerian roads. As a result, these larger processors tend to operate far below their capacity, as product struggles to reach processing plants within its two-day shelf-life. The government, as a part of its efforts to strengthen cassava value chains, has announced its intention to set up several large-scale, commercial plants across the country. But without improvements to roads and other critical aspects of market access, it is unclear what kind of an impact such plants might have.

Knowledge of market orientation by traders in terms of consumers' behaviour helps suppliers and traders to decide on the products to handle which have consumer market face. A comparison of incomes from the cassava products gives an idea of the value differentials of the cassava products. This also informs the participation of value chain actors on the line of value addition and marketers of the cassava products to trade on.

The economic value of a product is adjudged by its market price (Olumola, 2007). It is determined by cost of production, utility it gives the consumer, availability of substitutes and its ability to been further used as a capital or raw material for production of other products. The concept of processing is central to value addition. Lawal and Jaiyeola, (2007) opined that value addition improves the shelf life of agricultural products and generates income for participants. Since most government interventions and policies are aimed at integrating the rural poor into the mainstream of the economy, one of the ways of achieving this is by adding value to their produce.

METHODOLOGY

The study was conducted in Nasarawa State, located between North Latitudes 7^o and 9^o and 7^o and 10^o East Longitudes (Nuhu and Amed, 2013) covering land area of about 27, 137.8sq Km representing 2.98% of the Nigeria land mass (www.tradingeconomics.com, 2014). It has an estimated population of 1,863,275 people (National Population Commission, 2006). Nassarawa State is characterized by a tropical sub-humid climate with two distinct seasons: the wet and dry with annual rainfall ranging from 1100 mm and 2000mm (NADP, 2013) and temperature of between 74^{o}F and 95^{o}F (https://weatherspark.c, 2020)

Stratified random sampling method was used in the three agricultural zones (Nasarawa north, made up of Akwanga, Nasarawa Eggon and Wamba LGAs; Nasarawa west, encompassing Karu, Keffi, Kokona, Nasarawa and Toto LGAs; and Nasarawa south housing Awe, Doma, Keana, Lafia and Obi LGAs of the State) to draw up 1,400 sample from the universal population comprising of cassava producers, processors and product marketers. Data were collected via questionnaire and analyzed using descriptive statistics for means and General Linear Model (GLM) for multiple means comparison of the cassava products prices.

GLM has features through univariate analysis of variance for multiple paired means comparison of samples (Nanjiang, 2016). The model according to Nanjiang (2016) is as

$$g(\mu_m) = \mu_m = \beta_0 + X_1\beta_1 + \cdots + X_p\beta_p + \gamma_2 = \gamma_m + \eta_1 + \gamma_2 + \cdots + \gamma_m$$

Where μ_m =P(Y≤m) and it provides regression analysis and analysis of variance for one dependent variable by one or more factors and/or variables (univariate ANOVA). The factor variables divide the population into groups; investigate interactions between factors as well as the effects of individual factors; used for factorial ANOVA with between-subject design. For multivariate ANOVA, it provides regression analysis and analysis of variance for multiple dependent variables by one or more factor variables or covariates. The modified and adopted Nanjiang, (2016) GLM model for the study was as:

$$g(\mu_m) = \mu_m = \beta_0 + X_1\beta_1 + X_2\beta_2 + X_3\beta_3 + X_4\beta_4 + X_5\beta_5 + X_6\beta_6 + X_7\beta_7 + \varepsilon$$

Where; μ_m= mean price (income) of a cassava product, η_m= sample size, β_0= constant assumption, $\beta_1 - \beta_7$= Coefficients of means variations, X_1= income from boiled cassava, X_2= income from cassava bread, X_3= income from cassava chips, X_4= income from cassava flakes, X_5= income from Garri, X_6= income from High Quality Cassava Flour (HQCF), X_7= income from cassava meat pie, ε = estimation error.

Post Hoc multiple comparison tests, once it has been established that differences exist among means, post hoc range tests and pairwise multiple comparisons can determine which means differ. These tests are used for between subjects' factors only.

RESULTS AND DISCUSSION

Mean income differentials of cassava value added products

In this analysis, seven cassava value added products were captured. These included boiled cassava root, cassava bread, cassava chips, cassava flakes, garri, High Quality Cassava Flour (HQCF) and meat pie. They had mean incomes of N555.00, N3,429.17, N225.00, 642.86, N3,642.86, N119.00, 127.66, N121, 288.37 and N1,490.00, respectively (Table1).

The position of the result may be informed by the value consumers attached to the various products which determine their prices in the market. Also, the value derived from each of the products varies and so the market demand. The result of this study confirms the findings of Aniedu *et al*., (2012) that cassava product which has large demand generates more income than the one with lesser market demand; hence significant variation may occur in their profit levels. Furthermore, Anyiro *et al*, (2016) explained this assertion that investors skew to products enterprise with larger market demand.

Table 1 showed that cassava chips, garri and HQCF had higher mean incomes than boiled cassava roots, cassava bread, meat pie and cassava flakes. This result reflects the findings of Ndirika (2011), PIN (2011) who reported higher figures for garri and HQCF over tapioca, fufu and abacha, and said products which can further be processed into other finished goods has more market value and attracts patronage than final products. Mbanasor (2012) said because HQCF can be used directly to prepare food, bake bread, meat pie and other snacks, it commands higher market value. Similarly, cassava chips are considered as raw material for animal feed and which can further be processed into cassava flour has greater value and demand in the market. Azogu (2010) said if a commodity is used for many purposes, it tends to have wider consumers and so its market value.

Mean incomes of boiled cassava roots, cassava bread, meat pie and cassava flakes were lower. This perhaps is the fact that they are final consumable products. They cannot be further processed, therefore, the demand for them are smaller than those of cassava chips, HQCF and garri. Also, cassava bread and meat pie are predominant in urban markets. Their demands are therefore limited. However, cassava flakes are obvious in rural markets than in urban markets, hence limiting its market demand. The implication of these is that processors of cassava roots into various products will always have market for their products. Table 1 is therefore important to intending investors who wish to invest in cassava value addition, they are informed of which cassava product(s) has large market demand and attracts more income.

Table 1: Mean Income of Cassava Value Added Products

Products	N Statistic	Minimum Statistic	Maximum Statistic	Mean Statistic	Std. Error
Boiled cassava	10	100	1200	555.00	106.575
Cassava bread	6	200	5000	3429.17	698.224
Chips	42	40000	2000000	225642.86	49631.436
Flakes	14	100	6000	3642.86	461.926
Garri	94	12000	370000	119127.66	8135.555
HQCF	215	10000	2000000	121288.37	15030.568
Meat pie	7	80	5350	1490.00	790.542

Source: Field survey, 2018

It was observed in this study that cassava processors were engaged in varied value addition lines. Some process cassava roots into only one product, others do so into multiple products based on the available technology to them. The study translates these numbers of processing activities into levels of value addition. Those that process cassava into only one product were at level 1. Those of them that do so into two and three products were at levels 2 and 3, respectively. The mean income of these categories of cassava processors were estimated (Table 2).

Actors who processed cassava roots into only one product appeared to have lesser income compared to those who processed cassava roots into two and three products depending on the product combination. Specifically, however, actors that produce only boiled cassava roots, cassava bread, chips, flakes, *garri,* HQCF and meat pie had mean incomes of ₦555, ₦3, 429.17 ₦ 196,666.67, ₦3, 642. 86. ₦ 172,319.15 ₦ 108, 683.72 and ₦ 1, 490, respectively. Those of them that processed cassava roots into cassava chips and HQCF recorded mean income of ₦ 147,102.33 and those that processed cassava roots into cassava chips and *garri* settled with mean income of ₦ 222,441.86.

Table 2: Mean Income of Cassava Processors by Levels of Value Addition

Descriptive Statistics **Products**	**Level**	**N** **Statistic**	**Minimum** **Statistic**	**Maximum** **Statistic**	**Mean** **Statistic**	**Std. Error**
Boiled cassava	1	10	100	1200	555.00	106.575
Bread	1	6	200	5000	3429.17	698.224
Chip/HQCF	2	215	10000	993000	147102.33	11845.789
Chip/HQCF/*Garri*	3	215	10000	2360000	222441.86	20472.987
Chips	1	42	40000	800000	196666.67	25650.462
Chips/*Garri*	2	94	12000	2275000	260191.49	37582.792
Flakes	1	14	100	6000	3642.86	461.926
Garri	1	94	12000	2275000	172319.15	35571.252
HQCF	1	215	10000	818000	108683.72	9818.070
Meatpie	1	7	80	5350	1490.00	790.542

Source: Field survey, 2018

Comparison of the mean incomes of the levels of cassava value addition (Table 3) indicates significant ($P<0.05$) difference between levels 1 (actors that processed cassava in to only one product), and levels 2 (actors that processed cassava in to two products) and 3 (actors that processed cassava in to three products). However, mean income differential of levels 2 and 3 of the cassava value addition were not significantly different. This means that processing cassava roots into multiple products especially those with large market demand is more economical.

Table 3: Mean Income Differential of Cassava Processors by Level of Value Addition

Multiple Comparisons **Dependent Variable: Income**	**(I) Level**	**(J) Level**	**Mean Difference (I-J)**	**Std. Error**	**Sig.**
Tukey HSD	2	1	58018.89*	18779.522	.006
	3	1	98955.89*	20940.489	.000
		2	40937.01	21874.112	.148

Based on observed means. The error term is Mean Square (Error) = 60663366416.219. * The mean difference is significant at the 0.05 level. Source: Field survey, 2018

CONCLUSION AND RECOMMENDATIONS

The study concluded that the various forms of cassava products demonstrates different value regime in the market with the processors having varied incomes depending on level of value addition and product combination. Therefore, it was recommended as follows:

Intending investors into cassava processing in the study area can do so into garri and HQCF. This is because they give higher return on investment than other products. Furthermore, there is large market (demand) for garri and HQCF as found in this study.

Processors are advised to process cassava roots into more than one product. It was found out that actors who processed cassava roots into two and three various products make more net income than those that do so into only one product.

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Land Use Conflict Between Farmers and Herders in Anambra State with Implications for Food Security

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K E Y W O R D S

Climate change,
Farmer-herder Conflict,
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Land Use

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A B S T R A C T

Herder-farmer conflicts threaten the livelihood resources of people particularly farming communities due to high dependence on natural resources for survival. The study described the personal characteristics of the respondents; identified the causes of the conflict between the farmers and the nomads; described the perceived socio-economic effects of conflicts and identified the coping strategies adopted by the farmers. Frustration-aggression and conflict theories guided the study. The primary data collected from 120 respondents using well-structured questionnaire were analysed with mean and multiple regression analysis. The findings revealed that women dominated crop farming by 61.67%, mean age was 42.83 with a household size average of 6 persons and mean size farm land of 2.45 hectares. The perceived causes of the conflict were land encroachment, crop damage by cattle, killing of stray cattle, inadequate grazing reserves for the nomads, indiscriminate bush burning and hatred for one another. The perceived socio-economic effects of the conflicts were reduction in cultivable farmlands, little or no seed/cutting for the next planting season, disruption in the transportation of farm produce and destruction of human lives and property. This study also showed that the coping strategies adopted by the farmers were formation of vigilant groups (86.67%), income diversification (85%) and combination of arable farming with other cash crops (71.67) amongst others. The study therefore recommends that the government should address issue of climate change, establish ranches, implement the open grazing ban and provide coping loan for farmers affected by the conflict.

INTRODUCTION

Livestock is the single largest land user and hence the need to study the relationship between indiscriminate grazing and how they affect food production (Food and Agriculture Organization, 2010). Farmer-herder conflict is becoming wide spread and a formidable challenge to agricultural production in Nigeria (Aluko, 2017). In time past, herdsmen and farmers used to have a symbiotic relationship because cattle served as means of transportation for daily goods and manure to fertilize the fields for farmers; the herdsmen in turn obtained grains and other farm produce from farmers (Ojiagu, Okafor and Michael, 2022).

Although conflicts between herders and farmers have been ongoing historically (Mbih 2020), their frequency and intensity are increasing (George, Adelaja, Vaughan and Awokuse. 2022). The recent spike in violence is as a result of the complex interactions between the changing nature of access to land in the region as a result of climate change, a rapidly rising population, the influence of elites on herders, and the undermining of traditional approaches to managing the farmer-herder relationship. However, rising population in the region is also putting pressure on farmers to increase food production. So, the expansion of farming activities invariably led to demand for farmlands and drastically reduced supply of grazing land, encroachment of flocks of cattle frequently on cultivated fields, their relationship is progressively characterized by violent conflicts. In addition to climate-related conflict issues, socio-economic dynamics are exacerbating the conflict.

Anambra has witnessed and still experiencing conflicts of grave proportion which vary in dimension and process between migrant and settler pastoralists and sedentary farmers usually occasioned by cases of rural land disposition, commodification and consequent life and livelihood implications (Kugbega and Aboagye, 2021). Also, Premium Times Nigeria (2021) reported that millions of farm crops were lost in terms of crops destroyed as well as lives lost in Anambra herdsmen and farmers' conflicts. Conflicts reduce food security through their adverse impacts on agricultural labor supply, production decisions (Arias, Iba˜nez, and Zambrano 2019), and outputs

(George, Adelaja, and Awokuse 2021). Conflicts affect the food accessibility dimension of food security through their harmful impacts on physical and economic access to food (Nnaji, Ma, Ratna, and Renwick, 2022). For the food utilization dimension, the adverse impacts of conflicts are usually captured through anthropometric outcomes (Martin-Shields and Stojetz2019). Finally, for the food stabilization dimension, the adverse effects of conflicts appear to be captured through its impact on variability of food prices and the value of food imports (George, Adelaja, and Weatherspoon 2020).

Conceptual and Theoretical frameworks

Food Security

World Bank (2019) defines food security as a threefold concept. These are food availability, food affordability and food accessibility. Food availability for households means ensuring sufficient food for the households through production. The above definitions, no doubt, point to at least two parts of this complex concept: access to available food and adequate nutrient intake for sustainable health (Udosen, 2021).

Herder

Sanni (2016) sees a herder in Nigeria as any individual who owns a large collection of livestock such as sheep, cows, goats, horses, donkeys, carmel and lots of others. A herder in Nigeria is someone who herds livestock and from the Fulfulde speaking ethnic group (Stevenson, 2016). The definition involves both the owner of the herd of animals and/ or the one that tends the herd whether in free range grazing or intensive system and irrespective of the tribe or ethnic region.

Conflict

Conflict according to Shittu (2020) can be defined as the opposition among social entities directed against one another. It distinguished from competition defined as opposition among social entities independently striving for something of which the supply is inadequate to satisfy all. Therefore, conflict could be well understood if defined on the basis of society, hence a social conflict. Coser (2010) as cited in Ojiagu *et al*. (2022) elaborates the definition of conflict as a struggle over values or claims to status, power, and scarce resources, in which the aims of the conflicting parties are not only to gain the desired values but also to neutralize, injure, or eliminate their rival.

The study is hinged on frustration-aggression and conflict theories:

Frustration-Aggression: This theory was originally conceived by Dollard and Miller (1939) as cited in Myers (2015) but later substantially refined by Berkowitz in 1969. The theory states that aggression is an outcome or result of blocking or frustrating a person's efforts towards a certain goal. The theory further posits that frustration caused by interference in goal-directed activity produces a 'readiness' for aggression which if 'triggered' can result in aggressive response. According to Rationis (2014), the trigger could be an insignificant element of behavior, such as a casual joke, gesture or mild criticism which would normally be overlooked, but to the frustrated individual who is already waiting for an opportunity to show his frustration it may provoke aggressive response or reprisal. In application to this study, the goal or aim of every farmer during planting season is to have bountiful harvest, then sell the farm produce and make profits. On the other hand, the herdsmen would always want to have well fed and healthy cattle and be able to make profits as well. When any of these expectations was not realizable, either by the herd (cattle) eating up and destroying the farmers' crops or that the farmer encroached on grazing reserves or use water reserved for cattle to irrigate their farms, aggression would be triggered. Either of the parties that felt frustrated to achieving their economic goals may decide to reprise as to show their displeasure and as a result, conflict will occur.

Conflict Theory: The lead proponent of this theory is Karl Marx (1818-1883). Marx's conflict ideology is "an analysis of inequality under capitalism and how to change it through confrontation" (Ritzer and Stepnisky, 2014). They argued that in capitalism, there is an inherent conflict of interests between two opposing classes. However, the basic tenet of the theory is that two opposing groups in the society always struggle for limited or scarce resources. Each group struggles to attain or acquire more resources and because they are scarce, struggle ensues between them. Every group tries to protect its own interest, thus blocking the progress of another in accessing that.

MATERIALS AND METHODS

The study was conducted in Anambra State, Nigeria. Anambra is a State in South Eastern Nigeria, created in 1991. It has 21 Local Government Areas (LGAs) which are divided into four Agricultural zones namely Aguata, Anambra, Awka and Onitsha. It lies within latitude 6^0 45^l and 5^0 44^l N and 6^0 36^l and 7^0 20^l E of the area within the Greenwich meridian (Anizoba, Chukwuma, Chukwuma, and Chinwuko (2015). The temperature ranges from 25.5 to 30.5^0C. The State has a population of 4,185,032 persons (N.P.C., 2006). Anambra State is predominantly occupied by the Igbo ethnic group, who by nature are farmers, fishermen, craftsmen and traders. Among the crops produced in the State are; yam, palm produce, rice, maize, cassava, cocoyam, vegetables and different varieties of fruit trees among others. In Anambra state, the story of farmer-herder crisis is endless. From Ayamelum to Ogbaru and to Ihiala; also, from Orumba to Anambra East and West as well as Awka North, there are incessant farmer-herder crisis. In these cases, destruction of farmlands, raping of women and killing of the locals reverberated.

Multi-stage sampling technique was used for sample selection. In the first stage, ten Local Government Areas (LGAs) where there are cases of farmer-herder crisis were purposively selected from all the agricultural zones of the state; These were Awka North, Awka South, Njikoka, Orumba North, Orumba South, Aguata, Ogbaru, Ihiala, Anambra East and Anambra West, giving 10 LGAs. In the second stage, two communities were purposively selected from the LGAs, due to incessant farmer-nomad conflicts, making a total of 20 communities. In the third stage, two villages were randomly picked from the 20 selected communities, giving 40 villages. The fourth stage involved the random selection of 3 crop farmers from each of the 40 villages, giving a total of 120 farmers. Questionnaire was used for primary data collection and was prepared according to the specific objectives of the study. Data were summarized and analysed using mean, frequency, percentage and multiple regression analysis.

RESULTS AND DISCUSSIONS

Demographic Characteristics of the Respondents

Table 1: Distribution of the farmers according to their personal characteristics

Variables	Frequency	Percentage	Mean
Sex			
Male	46	38.33	
Female	74	61.67	
Age (years)			
Below 20	0	0	
21-30	18	15	
31-40	32	26.67	42.83
41-50	42	35	
51-60	20	16.67	
61 and above	8	6.66	
Marital Status			
Married	80	66.67	
Single	30	25	
Widow/widower	10	8.33	
Level of Education			
No formal Education	9	7.5	
Primary Education	18	15	
Secondary Education	77	64	
Tertiary Education	16	13.33	
Household Size			
1-5	36	30	
6-10	84	70	6
11-15	0	0	
Years of Farming Experience			
0-5	40	33.33	8
6-10	42	35	
11-15	32	26.67	
16-20	6	5	
Farm Size	38	31.76	
0-1.9	74	61.67	2.45
2-3.9	8	6.66	
4-5.9	0	0	
6-7.9			
Conflict Experience			
1-3	36	30	
4-6	80	66.67	5
7-9	4	3.33	
Total	120	100	

Source: Field survey, 2022.

The results for this study showed that most of the farmers are educated married women within the age range of between 41-50 years and mean household size of 6 persons. This implies that the farmers are able to withstand the stress associated with farming and also used more of family than hired labour for food. Farmers with formal education are privileged to have early contact with new innovations and improved technologies which are designed to improve output and productivity, moreover such farmers are early adopters and risk aversion tendency reduces with formal education. This implies that farmers- herders' conflict is imminent in the area and this justifies the high price of food and food products because farmers could not farm due to fear of having conflicts with the herders. These findings are in line with Emaziye, Emaziye, and Udonadi (2022) who also states that mostly young, married and educated women are engaged in production of food in Delta State, Nigeria. Most have mean had farm size of 2.45 hectares implying that bulk of the farmers were smallholder farmer with farming and conflict experiences of above 16 and 7 years, respectively.

Farmers' Perceived Causes of the Conflict between them and the Nomads

The perceived causes of the conflict between them and the nomadic herders in Anambra State as presented in Table 2 were land encroachment, crop damage by cattle, killing of stray cattle, inadequate grazing reserves for the nomads, indiscriminate bush burning, perceived hatred and climate change. This implies that that farmers would be forced to retaliate when their farms are being destroyed by cattle or stray cattle led by the nomads. The findings corroborate with Ojiagu *et al* (2022) who reports that struggle over grazing land, deliberate grazing of cattle on crops and Climate (weather) change are the causes of farmer-herder conflicts.

Table 2: Distribution of the respondents' perceived causes of conflict

Perceived Cause	Mean	Decision Rule
Land Encroachment	3.58	Agree
Crop damage by cattle	3.35	Agree
Killing of stray cattle	2.80	Agree
Lack of access to water points	2.27	Disagree
Inadequate grazing reserves	3.23	Agree
Pollution of water points	2.30	Disagree
Indiscriminate bush burning	3.42	Agree
Disregard	1.80	Disagree
Land Tenure System	2.25	Disagree
Perceived Hatred	2.62	Agree
Climate Change	2.92	Agree

Source: Field survey, 2022. Decision rule: Agree if mean ≥2.5

Farmers' Perceived Socio-economic Effects of the Conflicts

The farmers' perceived effects of the conflicts between them and the nomadic herders include reduction in cultivable farmlands, lack of access to seed/cutting, disruption in the transportation of farm produce, reduction of hired labour, farm produce is usually stolen, market activities is affected, abandonment of farmland, reduced family labour, lack of information and contact with extension agents, and destruction of human lives, properties and development of the community. The finding is expected as the fear for loss of lives and properties would make the farmers to reduce the number of farmlands they cultivate especially those far from human inhabitation out of fear of being attacked by herders while working in the farm. Reduced farming means there will be lack of seeds/cutting for the next planting season; farmlands are also abandoned leading to theft of the produce. The findings are in conformity with Okeke (2022) reports that the herdsmen and farmers' conflicts adversely affect the socio-economic development in Anambra state by draining of federal and state governments' resources meant for developmental purposes; inhibiting the delivery of public services; discouraging potential foreign and local investors investing in the state/country; affecting rapid economic growth; destructing lives and farmland among others. The farmers perceived effects of the conflicts are presented below in Table 3.

Table 3: Distribution of the respondents' perceived effects of the conflicts

Perceived Effects	Mean	Decision Rule
Reduction in cultivable farmlands	3.33	Agree
Little or no seeds/cuttings	3.35	Agree
Disruption in the transportation of farm produce	3.27	Agree
Reduction of hired labour	3.10	Agree
Farm produce is usually stolen	2.65	Agree
Market activities are affected	3.22	Agree
Abandonment of farmland	3.22	Agree
Reduced family labour	2.83	Agree
Lack of information and contact with extension agents	2.92	Agree
Destruction of human lives, property and development	2.77	Agree

Coping Strategies Adopted by the Farmers

The coping strategies adopted by the farmers were formation of vigilant groups (86.67%), income diversification (85%), combining arable production with other cash crops (71.67%), walking in group to the farm (65%), seeking assistance from the government (61.67%), asking for help from family and friends (41.67%) and securing insurance for farm enterprise (35%). This implies that the farmers did not just fold their hands waiting for government's intervention, rather they resorted to self-help, to ensure they still survive in the midst of crisis.

Table 4: Distribution of the coping strategies adopted by the farmers

S/N	Coping Strategy	Frequency	Percentage	Ranking
1	Vigilant groups are formed	52	86.67	1
2	Walking in groups to the farm	39	65	4
3	Secure insurance for farm enterprise	21	35	7
4	Income diversification	51	85	2
5	Seeking assistance from the government	37	61.67	5
6	Asking for help from family and friends	25	41.67	6
7	Combine arable production with other cash crops	43	71.67	3

Source: Field survey, 2022. Multiple Responses Recorded*

CONCLUSION AND RECOMMENDATIONS

The study found that married females who are also young and educated dominated food production with average household size of 6 persons and mean farm size of 2.45 hectares. The perceived causes of the conflict found by this study were land encroachment, crop damage by the cattle, among others. The effects of the conflict were reduction in cultivable farmlands, little or no seed/cutting, among others. This study also shows that coping strategies used by the farmers were mostly formation of vigilant groups and income diversification. The study therefore recommended that the focus of the government and all concerned stakeholders should shift from just ending the conflicts to, rather addressing the root cause and putting sustainable structures in place for a lasting solution guaranteeing food security. Since herders are mostly attracted to small farms in Nigeria establishing a community-wide solution where large farms cooperate with smaller farms would help prevent these conflicts, boost large scale food production and improve food security. Also, the government should address the issue of climate change, establish ranches, enforce the open grazing ban and provide coping loan for farmers affected by the conflict.

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Analysis of Climate Change Perception by Farming Households in Ohaozara Local Government Area of Ebonyi State, Nigeria

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K E Y W O R D S

Climate change,
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A B S T R A C T

This study analyzed climate change adaptation perception by farming households in Ohaozara Local Government Area of Ebonyi State. The study ascertained the perception of the farming household on the effects of climate variability and identified constraints to climate change adaptation measures. Multi-stage random and purposive sampling techniques were used for the selection of 100 respondents. Results shows that loss of crops ($\bar{x}$=2.98), increase in frequency of drought ($\bar{x}$=2.95), decrease in agricultural yield ($\bar{x}$=2.94), high cost of food ($\bar{x}$=2.92), erosion ($\bar{x}$=2.89), loss of income ($\bar{x}$=2.87), poor supply in the market ($\bar{x}$=2.84) were perceived effects of climate change. Further analysis identified individual/financial, natural, social/institutional and environmental constraints as constraints to farmers' adaptation strategies. Thus, there is high level of awareness and perception of climate change effects in the area. The study recommended that policy makers and extension services should enlighten farmers more about climate change and adaptation strategies, identified constraints should be addressed by both private and government sectors. Development agenda should incorporate climate change adaptation policies.

INTRODUCTION

Climate change is mainly induced by human activities on the environment, though the contributions of natural phenomena cannot be over-emphasized. Human activities greatly contribute to increase in greenhouse gases (GHGs) emissions into the atmosphere leading to unusual increase in global temperature. Climate change according to Onu and Ikechi (2016) is one of the major global problems threatening the survival of humans, animals, crops and the entire ecosystems. Emeka (2008) asserts that climate change is one of the global threats with serious impact on agriculture, natural ecosystem, water supply, health, soil and atmosphere, which are all elements that constitute the support for long term sustainability of most production processes on earth.

Climate change is perceived differently at different levels of conceptualization depending on socioeconomic variables, location and livelihood activity (Digg, 1991; West *et al*. 2007). Depending on the perception and awareness, farmers make certain changes on their livelihood patterns that occur through climate change (Kessler, 2006). Adaptation in its simplicity is how perception of climate change is translated into decision-making process (Bryant *et al*., 2000) by different individuals in different sectors. Their perception determines the course of action taken, thus different individuals may have different courses of action consequent on the impact, depending on their different characteristics and prevailing environmental conditions.

In order to adapt to climate change, individuals must first perceive that changes are taking place (Madison, 2007; As faw and Lipper, 2011) and their choices and farming practices are based on a set of expectations about weather, markets and other factors which are based upon their own experiences (Madison, 2007), as well as information they may obtain from a range of sources including extension agents. Asfaw and Lipper (2011) and Pannell (2009) point out that if farmers are to adopt land conservation techniques, they must first be aware that the technology exists and perceive that it is profitable. Understanding why farmers do what they do can improve the quality of policy and programming decisions at various levels (Leagans, 2011).

In Ebonyi State, droughts have been relatively less persistent, while rainfall is observed to be increasing and temperature increases and reduces moderately over the years compared with Northern Nigeria (Okorie *et al*., 2012). Farmers depend on the natural environment for their livelihood due to poverty and paucity of resources. According to Nwalieji and Uzuegbunam (2012). Farmers in the state suffered reduction in crop yield and grain quality, reduction of farm land by flood, high incidence of weeds, pests and diseases, decrease in soil fertility and the surge of human diseases such as meningitis, malaria and cholera. Extreme variation in climate variables has made these farmers vulnerable and helpless (Anayo, 2010).

The State was seriously affected by flood in 2012. There were cases of displacement of communities, loss of rivers, loss of farmland, destruction of high ways, link roads and infrastructure in the State. Huge amounts of money set aside for other purposes were used to ameliorate the effect of the natural disaster. These changes in the environment affected the composition of rural livelihoods through their impacts on agricultural production and income. This study therefore analyzes climate change adaptation among rural farm household in Ohaozara L.G.A of Ebonyi State, Nigeria.

The study therefore, seeks to find solutions to the following research questions. What is the level of awareness of Climate change among farming households in the area? What are the perceptions of the farm households on the effects of climate variability on choices of adaptation in the area? What are the constraints of climate change adaptation among the farm households?

Objectives of the Study

The broad objective of the study was to analyze climate change perception among rural farming households in Ohaozara Local Government Area of Ebonyi State, Nigeria. The specific objectives were to:

i. ascertain the perception of the farming household on the effects of climate variability on their choices of adaptation in the area; and
ii. identify the constraints of climate change adaptation measures among the farming households in the study area.

MATERIALS AND METHODS

The study was carried out in Ohaozara Local Government Area of Ebonyi State. The area comprises of nine (9) autonomous communities, these communities are Ugwulangwu, Mgbom Ugwulangwu, Uburu, Etiti Uburu, Eweze Uburu, Okposi, Okposi Okwu, Mgbom N'Echara, and Enu Uburu. Ohaozara lies between latitude 8^0, 5^1 and 8^0, 3^1 East and longitude 6^0,40^1 and 6^0,45^1 North. It covers an area of about 296.72m^2 with projected population of 148,317 peoples (NPC, 2006).The mean temperature is between 27^0C and 28^0C and the prominent climatic seasons are rainy season, lasting from April to October, and dry season, lasting from November to March.

Multi-stage random and purposive sampling techniques were used for the selection of five (5) communities. Two (2) villages were purposively selected to make a total of 10 villages. Ten (10) farm households' heads were randomly selected to make a total of 100 respondents. Primary data were collected through the use of structured questionnaire and interview schedule. Mean scores generated from a four point likert scale and factor analysis were used to analyze the data.

Model Specification

Factor Analysis Model

Factor analysis is a statistical method used to describe variability among observed correlated variables in terms of a potentially lower number of unobserved variables called factors.

In order to obtain the factor loadings of each of the variables necessary for achieving aspects of objective v, factor analysis model presented below was used.

$$\text{Xij} = \varphi_{i1}F_{i1} + \varphi_{i2}F_{i2} + \varphi_{i3}F_{i3} + \cdots \varphi jmF_iK + e_ij$$

Where; Xij = Observation on variable Xj for the ith sample number, F_ik = Score on factor Fk (k = 1,2,3,…….,m), F1-Fm = Common factors, e_ij = The value on the residual variable Ej for the ith sample member, φji………φjm = Factor loadings (regression weights)

The associated assumptions were applied accordingly while the suitable number of factors was subjectively selected based on varimax rotated factor matrix to be obtained using SPSS analytical software. The exploratory factor analysis techniques using the principal factor model with interactions and varimax rotation will be adopted. The factor loading under each constraint (beta weight) represents a correlation of the variables (constraint areas) to the identified constraint factors and has the same interpretation as any correlation coefficient. Kaisier's criterion using factor loading of 0.40 and above in naming and interpreting the factors and constraint variable were adopted as applied by Nwibo and Eze (2013).

RESULTS AND DISCUSSION

Perception of the Farming Households on the Effects of Climate Change on their Choices of Adaptation Measures in the Area.

The result obtained was presented in Table 1. The result of the analysis shows that the major perception of the farm households that affect their choices of adaptation were loss of crop due to flood ($\bar{x}$=2.98), increase in frequency of drought ($\bar{x}$=2.95), decrease in agricultural yield ($\bar{x}$=2.94) and high food price ($\bar{x}$=2.92). This is followed by increase in rate of erosion ($\bar{x}$=2.89), loss of income ($\bar{x}$=2.87), poor supply in the market ($\bar{x}$=2.84), increase in temperature ($\bar{x}$=2.82), increase of pest and diseases ($\bar{x}$=2.78), depletion of household asset ($\bar{x}$=2.73), decrease in precipitation ($\bar{x}$=2.72), land degradation ($\bar{x}$=2.66), decrease in soil fertility ($\bar{x}$=2.64) and increase in precipitation ($\bar{x}$=2.63). Others are poverty ($\bar{x}$=2.55) and lack of access to the market ($\bar{x}$=2.51). This implies that loss of crop due to flood, increase in frequency of drought, decrease in agricultural yield and high food price are the major perception of the farm households that affect their choices of adaptation in the study area. Umeh and Chukwu (2014) and Onyeneke *et al* (2012) obtained similar result in the study area.

Table 1: Mean Score Distribution of the Respondents Based on their Perception on Effects of Climate Change on their Choices of Adaptation Measures.

Perception	Mean($\bar{X}$)	Remark
Increase in precipitation	2.63	Accepted
Decrease in precipitation	2.72	Accepted
Increase in temperature	2.82	Accepted
Decrease in temperature	2.43	Rejected
Decrease in soil fertility	2.64	Accepted
Loss of crop due to flood	2.98	Accepted
Loss of income	2.87	Accepted
Increase in frequency of drought	2.95	Accepted
Increase of pest and disease	2.78	Accepted
Migration	2.34	Rejected
Depletion of household assets	2.73	Accepted
Increase in rate of erosion	2.89	Accepted
Poor supply in the market	2.84	Accepted
Decrease in agricultural yield	2.94	Accepted
Land degradation	2.66	Accepted
High food price	2.92	Accepted
Changing from farming to non-farming activities	2.08	Rejected
Loss of infrastructure such as school, road andhospital	2.02	Rejected
Poverty	2.55	Accepted
Lack of access to the market	2.51	Accepted

Source: Field Survey, 2019.

Constraints to Climate Change Adaptation among the Farm Households in the Study Area

Table 2 shows the result of the factor analysis. The first factor was named individual/financial factors; they included High cost of input (0.837), Lack of formal education (0.643), Limited availability of land for farming (0.412), High cost of farmland (0.520), Inherited system of land ownership (0.838), Poor infrastructural development (0.838), High cost of irrigation facilities (0.716), high cost of fertilizers and other inputs (0.860), High cost of improved varieties (0.737), Non-availability of farm labour (0.667), limited income (0.743), Non-availability of processing facilities (0.544) and High cost of processing facilities (0.687). This showed that individual/financial constraint is one of the key problems facing the rural farm household adaptation to climate change in the study area. This is in agreement with the observation made by Okeke (2012), that the major problem faced by farmers in Anambra State is lack of capital/high cost of inputs.

Table 2: Varimax Rotated Component Matrix on Constraints to Climate Change Adaptation

Constraints	Factor 1 individual/ Financial constraints	Factor 2 Natural constraints	Factor 3 Social/ Institutional	Factor 4 environmental
Unpredictable weather	0.216	0.719	-0.611	0.345
Inadequate government support	0.305	0.333	0.705	0.286
Poor weather information	-0.800	-0.142	0.629	-0.456
Land tenure issues	0.307	0.229	0.758	0.349
High cost of input	0.837	0.344	0.218	-0.543
Inadequate extension officers	0.267	0.056	0.805	0.312
Lack of formal education	0.643	0.331	0.083	-0.766
Poor soil fertility	0.205	0.272	0.222	0.567
Limited availability of land for farming	0.412	0.273	0.324	0.334
High cost of farmland	0.520	-0.666	0.330	0.330
Inherited system of land ownership	0.838	0.206	0.351	0.321
Poor access to information sources	0.259	0.111	0.515	-0.543
Non-availability of credit facilities	0.341	0.258	0.853	0.278
High cost of irrigation facilities	0.716	-0.019	-0.611	0.331
Non-availability of farm inputs e.g. improved seeds	0.305	-0.663	0.705	-0.738
Inadequate knowledge of how to cope or build resilience	0.207	0.029	0.958	0.089
High cost of improved varieties	0.737	0.344	0.318	0.345
Non-availability of farm labour	0.667	-0.453	-0.755	0.087
Lack of access to weather forecast technologies	0.321	0.042	0.875	-0.651
Government irresponsiveness to climate risk management	0.056	0.237	0.678	0.278
Non-availability of storage facilities	0.243	0.321	0.560	0.212
Limited income	0.743	0.331	0.208	-0.422
Non-availability of processing facilities	0.544	-0.881	0.067	0.078
High cost of processing facilities	0.687	0.202	0.341	0.311
Traditional beliefs/ practices e.g. on the commencement of farming season etc	0.066	0.215	0.508	0.233
Poor agricultural extension service delivery	0.034	0.344	0.432	0.328
Lack of capacity of extension personnel to build resilience capacity of farmers on climate change	0.271	0.281	0.671	0.326
Poor information on early warning systems	0.043	0.213	0.754	0.341

Source: Field Survey, 2019.

The second most important was natural factor which is Unpredictable weather (0.719). This is in line with the observation made by Olalinde, Manyoung and Akintola, (2007), that majority of the farmers had their crops affected by drought, flood, wind and storm, and diseases and pest, these they categorized as natural risks, noting that the implication is that crop yield could be low due to the negative effects of these natural occurrence.

Furthermore, factor 3 was considered and named social/institutional constraints which include Inadequate government support (0.705), Poor weather information (0.629), Land tenure issues (0.758), Inadequate extension officers (0.805), Poor access to information sources (0.515), Non-availability of credit facilities (0.853), Non-availability of farm inputs e.g. improved seeds (0.705), Inadequate knowledge of how to cope or build resilience (0.958), Government irresponsiveness to climate risk management (0.678), Non-availability of storage facilities (0.560), Traditional beliefs/ practices e.g. on the commencement of farming season etc (0.508), Poor agricultural extension service delivery (0.432), Lack of capacity of extension personnel to build resilience capacity of farmers on climate change (0.671) and Poor information on early warning systems (0.754).

Finally factor 4 was named environmental constraints due to the factors that loaded high in it; these include Poor soil fertility (0.567).

From the study, it was observed that individual/financial and social/institutional constraints pose the greatest threat to adaptation of climate change followed by natural factors and environmental factors. This corresponds to the work of Onyeneke *et al* (2021).

CONCLUSION AND RECOMMENDATIONS

The major perception of the farm households about climate change were: loss of crop due to flood, increase in frequency of drought, decrease in agricultural yield and high cost of food prices. Based on the findings of this research, the study recommends that policy makers and extension services should enlighten farmers more about climate change and adaptation strategies, identified constraints should be addressed by both private and government sectors and development agenda should incorporate climate change adaptation policies.

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Socioeconomic Determinants of Crop Production Strategies Adopted by Organic Farmers in Onicha Local Government Area of Ebonyi State, Nigeria

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K E Y W O R D S

Crop production strategies,
Socioeconomic determinants,
Organic farming,
Ordinary least square
Regression.

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A B S T R A C T

This paper assessed socioeconomic determinants of crop production strategies adopted by organic farmers in Onicha Local Government Area of Ebonyi State, Nigeria. Specifically, the study analyzed the effects of socioeconomic characteristics of the organic farmers on the type of crop production strategies adopted and determined constraints to organic farming in the study area. Multi-stage random and purposive sampling techniques were used to select the respondents. Primary data collected were analyzed using ordinary least square multiple regression and factor analysis. The null hypothesis was tested at 5% level of significance. Result showed a high value of R2 (87%) which signifies that the socioeconomic characteristics of the respondents had significant effects on the type of crop production strategies they adopted. The independent variables were positively signed and statistically significant at various levels; indicating positive relationship with the dependent variable. Four major constraints identified were: economic/institutional, social, financial and technological constraints. The study recommended that the respondents should be well trained in organic farming and its applications in order to ensure sustainable production of crops in the area.

INTRODUCTION

Organic agriculture is a technique of naturally producing quality crops, vegetables or animals without harming the environment, the people, the animals as well as other microorganisms that are living around (Singh, 2021; Orji, 2013). Organic farming practice is eco-friendly and works in agreement with nature (Ezeh, Enyigwe, Egwu, Eze, Agbom and Nwofoke, 2022). In organic farming, best traditional farming practices and techniques in combination with modern knowledge of science and technology are applied. Organic Farming emphasizes the use of renewable natural resources and their recycling (Ezeh *et al*, 2022). It eliminates the use of synthetic pesticides, growth hormones, antibiotics and gene manipulation in farming. Lampkin (2010) reported that organic farming systems rely on crop rotation, crop residues, animal manures, legumes, green manures, off-farm organic waste and aspects of biological pest control to maintain soil productivity and tilt, to supply plant nutrients and to control insects, weeds and other pest. Singh (2021) defines organic agriculture as the method which involves the cultivation of plants and rearing of animals in natural ways.

Crop production is becoming more widely recognized as a requirement for food security, nutrition and sustainability (Osuji *et al*, 2022; Osuafor *et al*, 2020). Crop producers are faced with a significant amount of crop uncertainty daily, hence diversification of crops serves as a major option to increasing and stabilizing income flow and also a source of employment (Osuafor *et al*, 2021). Farmers practice crop production diversification to maximize the use of land and other resources by planting varieties of food crops on their farmland (Ojo, Ojo, Odine and Ogaji, 2014). In several instances, diversification of cropping system and/or introduction of new cropping systems have been used to retain or to enhance the value of natural resources, principally land and water (Ojo *et al*, 2014; Saraswati *et al*, 2011). The past decades have been characterized by escalating public concern towards nutrition, health and food safety issues. Consumers perceive relatively high risks associated with the consumption of conventionally grown produce compared with other public health hazards (Williams and Hammit, 2011). Therefore, it seems that the extensive use of chemicals and anti-biotic in inorganic food production technology has compelled the health conscious people to explore and support organic farming methods in agriculture.

In Nigeria, there seems to be a growing general interest in organic farming and crops over the past few years. This is demonstrated by the rising consumer demand for organic food crops and the number of publicly supported research and policy initiatives related to the production of organic foods. It is generally believed that organic farming with its reliance on natural inputs and labour could materially advance diversification of crop production (Mafimisebi *et al*, 2019).

There exist a dearth of knowledge on the socio-economic determinants of vegetable crop production strategies adopted by organic farmers in Onicha Local Government Area of Ebonyi State. Thus, this paper was designed to scientifically investigate socioeconomic determinants of crop production strategies adopted by organic farmers in Onicha Local Government Area of Ebonyi State.

Objectives of the Study

The broad objective of the study was to determine socioeconomic determinants of crop production strategies adopted by organic farmers in Onicha Local Government Area of Ebonyi State, Nigeria. The specific objectives were to:

i. examine the effects of the socioeconomic characteristics of the organic farmers on the type of crop production strategies adopted; and
ii. determine constraints to organic farming in the study area.

Hypothesis

H_0: The socioeconomic characteristics of the organic farmers do not significantly influence the type of crop production strategies adopted.

METHODOLOGY

The study was carried out in Onicha Local government Area (L.G.A) of Ebonyi State. It is made up of 8 (eight) autonomous communities, namely: Onicha Igboeze, Igboeze Onicha, Ukawu, Isuokoma, Abaomege and Oshiri. The L.G.A has a land mass of approximately 559.62 sq.km and lies within latitude 6° 101 N and longitude 7.461 E and 8.151W (Ebonyi State Ministry of Land, Survey and Urban Planning, 2006). It has a population of 117,832 males and 118,777 females giving a total population of 236, 609 (NPC, 2006). In Ebonyi State, smallholder crop producers cultivate the majority of the crops such as rice, cassava, yam, potatoes, plantain, maize and vegetables (Onyeneke, Umeh and Onyeneke, 2023; Ezeh *et al*, 2019). Multi-stage sampling techniques was used for the selection of respondents for the study. Five (5) communities were randomly selected from Onicha L.G.A of Ebonyi State. Two (2) villages were randomly selected from each of the five (5) communities to make a total of 10 villages. Nine (9) farmers were randomly selected from each of the 10 selected villages to make a total of 90 respondents. Primary data were collected through the use of a well-structured questionnaire administered to the respondents. Objectives I and II were achieved using multiple regression analysis and principal component factor analysis respectively. The null hypothesis was tested at 5% level of significance with F-test.

Model Specification

Multiple Regression Analysis

$$Y = f(x_1, x_2, x_3, x_4, x_5, x_6, x_7, x_8, x_9, x_{10}) \quad (1)$$
$$Y = a_0 + a_1 x_1 + a_2 x_2 + a_3 x_3 + a_4 x_4 + \ldots a_{10} x_{10} + et \quad (2)$$

Where:
Y = Crop production strategies used (Number)
X_1 = Sex (dummy: male = 1, female = 0)
X_2 = Age (years)
X_3 = Educational level (years)
X_4 = Marital status (dummy: married = 1, single = 2, widowed = 3)
X_5 = Farm size (hectare)
X_6 = Household size (Number)
X_7 = Annual income (Naira)
X_8 = Extension contact (Yes = 1, No = 0)
X_9 = Farming experience (Years)
X_{10} = Membership of cooperative society (Yes = 1, No = 0)
a_0 = Constant
$a_1 – a_{10}$ = Parameters
et = Error term

Principal Component Factor Analysis Model

The exploratory factor analysis techniques using the principal factor model with interactions and varimax rotation was adopted (Eze and Nwibo, 2014). Principal component factor analysis with varimax-rotation and factor loading of 0.50 was used. Variables with factor loading less than 0.50 and variables that loaded in more than one factor will be discarded following the study of Madukwe (2004). The principal component factor analysis model is stated thus:

Y_1 = a11 Vo_1+ a12 Vo2+***+a_1n Von - - - - - - - (3)

Y_2 = a21Vo_1+a22 Vo2+***+a_2nVon - - - - - - - (4)

Y_3 = a31Vo_1+a32 Vo2+***+a_3nVon - - - - - - - (5)

Yn = aniZ_1+an2Vo2+***+ anVon - - - - - - - (6)

RESULTS AND DISCUSSION

Effects of Socioeconomic Characteristics of Organic Farmers on the Type of crop Production Strategies Adopted by Farmers in Onicha L.G.A

The result is presented in Table 1. Result of multiple regression analysis in Table 1 shows that the coefficient of multiple determination (R^2) of the regression model was 0.867 (87%) indicating that about 87% variation in the dependent variable (crop production strategies adopted) was caused by combined effects of changes in the explanatory variables (socio-economic characteristics) of the farmers. The high value of R^2 (87%) signifies that the socioeconomic characteristics of the respondents had significant effects on the type of crop production strategies adopted. The coefficient of multiple determination (R^2) of 87% was in numerical value closely related to the adjusted R^2 (85%), while the overall standard error of estimated was (SEE = 0.38592). The statistical reliability of the estimates of regression co-efficient was established using standard errors from the estimates. Most of the explanatory variables were significant at 1%, 5% and 10% levels of significance. But, the overall significance of the regression was shown by (F-statistics = 34.960) and low value of Durbin –Watson Constant (DW = 1.186).

Gender (X_1) was positively signed. This implies that there is positive relationship existing between sex of the farmers and type of crop production strategies adopted. It means that there is no gender difference in the number of crop production strategies adopted by organic farmers in the area.

Age (X_2) bore positive sign and was statistically at 5% level of significant; showing positive relationship. This means that older farmers employed more crop production strategies than younger ones. This corresponds to the work of Umeh and Chukwu (2013b).

Education (X_3) had positive sign and was statistically significant at 1%. The high significance of education implies that it is an important factor in this regard. This is because educated farmers are understand and adopt technologies easily than illiterate farmers. This result corresponds with the findings Chukwu *et al*. (2016).

Marital status (X_4) was positively signed and also significant at 10% showing that both married and single organic farmers employed some crop production strategies in the area.

Furthermore, farm size (X_5) bore positive sign and was statistically significant at 5% level of significant; showing that the higher the farm, size the more the number of strategies adopted. This is true and conforms to the a priori expectations because farmers with more farm size will have enough space to undertake farming activities.

Household size (X_6) was positively signed, indicating positive relationship. This implies that increase in household size would lead to a corresponding increase in the number of crop production strategies adopted by the household. This conforms to Umeh and Chukwu (2013).

Also, annual income (X_7) had positive sign indicating that there was positive relationship. Thus, the higher the annual income of the respondents the higher the number of crop production strategies they would adopt.

Finally, extension contact (X_8) and farming experience (X_9) were positively signed and statistically significant at 5% level of significance revealing positive relationship with the dependent variable. But, membership of cooperative societies (X_{10}) bore positive sign and was statistically significant at 10%. The result is regressed below:

$$\mathbf{Y = -2.275 + 0.006x_1 + 0.014x_2 + 0.006x_3 + 0.478x_4 - 0.001x_5 + 0.023x_6 + 0.485x_7 + 0.005x_8 + 0.682x_9 + 0.234x_{10}}$$

(0.403)*(0.009)(0.011)*(0.008)***(0.054)*(0.000)**(0.019)**(0.090)* (0.024)***(0.786)** (0.543)***

Table 1: Multiple Regression Analysis on Effects of Socio-economic Characteristics of the Organic Farmers on the Type of Food Production Strategies Adopted.

Variable	Variable names	Estimated coefficients	Standard error	T-value
a_0	Constant	-2.275	0.403	(-5.643) *
X_1	Gender	0.014	0.011	(1.286) *
X_2	Age	0.006	0.009	(0.654) **
X_3	Educational level	0.005	0.008	(0.629) ***
X_4	Marital status	0.478	0.054	(8.813) *
X_5	Farm size	0.001	0.000	(1.608) **
X_6	Household size	0.023	0.019	(1.243) **
X_7	Annual income	0.485	0.090	(5.370) *
X_8	Extension contact	0.005	0.024	(0.207) ***
X_9	Farming experience	0.682	0.786	(0.867) **
X_{10}	Membership of cooperative society	0.234	0.543	(0.431) *
	R^2	0.867		
	Adjusted R^2	0.846		
	F-ratio	34.960		
	SEE	0.38592		
	DW	1.186		

Source: Field survey, 2022. *= Significant at 10%,**= Significant at 5%,***= Significant at 1%

Constraints to Organic Agriculture in the Study Area

Factor analysis was used to determine constraints to organic agriculture in the study area. Table 2 showed the varimax rotated component matrix on constraints militating against organic agriculture in the study area. From the field data collected, four (4) major constraints were extracted based on the responses of the respondents. Only variable with constraints loading of 0.40 and above at 10% overlapping variance (Ashley *et al*; 2006, Madukwe, 2004) were used in naming the constraints. Variable that loaded in more than one constraint were discarded while variables that have constraints loading of less than 0.40 were not used.

Factor 1 was considered and named institutional constraints due to the variable that loaded high under it. This high loading variable include reduced yield and income for a time (0.761), limited government support (0.543), output/marketing problems (0.809), shortage of biomass(0.732), non-availability of farm inputs (0.644), lack of appropriate agricultural policy (0.694), low production (0.532) and lack of quality standards for bio-manure (0.732). According to Dorward and Kydd (2015), businesses in rural areas are attributed to weak information on potential production type and innovations. Saxena (2018) further stated that producers are often in agricultural practices, but not in effective and efficient organic agricultural practice.

Also factors 2 was considered and named social constraints because of the factors that loaded high under it. These include: lack of knowledge and skill (0.856), accessing organic information is difficult (0.524) and lack of awareness (0.688).

Moreover, after critical consideration of the constraints, factor 3 was named financial constraints due to the factors that loaded high under it. These include: high input costs (0.415), lack of financial support (0.810), inability to meet the export demand (0.471) and lack of capital (0.915).

Finally, factor 4 was considered and named technological constraints due to the factors that loaded high under it which was inadequate supporting infrastructure (0.568).

Table 2: Varimax Rotated Component Matrix on Constraints to Organic Agriculture in the Study Area

	Variable names	Factor 1 Institutional Constraints	Factor 2 Social Constraints	Factor 3 Financial Constraints	Factor 4 Technological Constraints
Vo_1	Reduced yield and income for a time	0.761	-0.079	-0.547	-0.034
Vo_2	Limited government support	0.543	0.020	-0.736	0.035
Vo_3	Lack of knowledge and skill	0.018	0.856	-0.227	-0.130
Vo_4	Accessing organic information is difficult	0.013	0.524	-0.632	0.165
Vo_5	Lack of Awareness	-0.130	0.688	-0.240	0.048
Vo_6	Output/ Marketing Problems	0.809	-0.041	0.155	0.252
Vo_7	Shortage of Bio-mass	0.732	-0.324	0.357	0.268
Vo_8	Inadequate Supporting Infrastructure	0.311	0.258	0.374	0.568
Vo_9	High Input Costs	-0.938	0.067	0.415	-0.005
Vo_{10}	Non-availability of farm Inputs	0.644	-0.553	0.242	0.237
Vo_{11}	Lack of appropriate Agriculture Policy	0.694	-0.524	0.069	0.316
Vo_{12}	Lack of Financial Support	-0.026	-0.400	0.810	0.298
Vo_{13}	Low production	0.532	-0.706	-0.101	0.108
Vo_{14}	Inability to Meet the Export Demand	0.351	0.345	0.471	0.044
Vo_{15}	Lack of Quality Standards for Bio-manures	0.732	-0.324	0.357	0.268
Vo_{16}	Lack of capital	-0.938	0.067	0.915	-0.005
Vo_{17}	Marketing problems	0.631	0.582	0.374	0.568

Source: Field Survey, 2022.

Hypothesis Testing

Ho: The null hypothesis which state that the socio-economic characteristics of the organic agricultural farmers do not significantly influence the type of crop production strategies adopted by the farmers in the study area was tested using F-test at 5% level of significance and the result showed that F-cal = 34.960, F-tab = 2.02.

Decision Rule: If F-cal > F-tab reject null hypothesis, otherwise accept the alternative.

Since F-cal (34.960) > F-tab (2.02), the null hypothesis was rejected and the alternative accepted. This implies that the socioeconomic characteristics of the organic agricultural farmers significantly influence the type of crop production strategies adopted by the farmers in the study area.

CONCLUSION AND RECOMMENDATIONS

This study had shown that the socioeconomic factors regressed significantly influenced farmers' involvement in organic agricultural practices in the study area. From the forgoing, the socioeconomic characteristics of the respondents such as education should be enhanced to enable them participate more in organic farming, the identified constraints should be tackled by government and private individuals to facilitate organic farming; farmers should be motivated through credit facilities and series of training on technical-know-how in organic farming in order to ensure sustainable production of food crops.

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Various Egusi Melon Seeds existing in Southwestern Nigerian Markets

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K E Y W O R D S

Egusi kernels,
Seed type,
Seed,
Colour,
Seed size

A B S T R A C T

Egusi is a common name for oil rich seeds of Egusi melon used mainly as soup condiment. The medium sized usually comes to mind anytime the name egusi is mentioned. But there exists a variety of crops in family Cucurbitaceae used for same purpose which is not commonly known even among the elites in Crop Science in Nigeria and beyond. In the course of a research on egusi, different types of seed forms were identified. There were six different types of egusi kernels (bojuri, itoo, serewe, igbaa, bara and wewe) based on size, colour and type sold in Nigerian markets; however, bara and serewe were the most common types of egusi found in Nigeria.

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INTRODUCTION

Egusi is botanically known as *Colocynthis citrullus* L. (Van der Vossen *et al*., 2004). It is a member of the Cucurbitaceae family. Egusi is a crop cultivated mainly for the seeds which is rich in protein, fat, carbohydrates and contains good quantities of most of the essential amino acids (Ayodele and Salami, 2006). Its major use is as a staple of many local diets. In West Africa, the seeds are made into pulp and added as a thickener to soups. They are also soaked, boiled, fermented and wrapped in leaves to form a favourite local food seasoning called ‘ogiri’ in Southeast Nigeria or they are roasted, pounded, wrapped in leaves and then boiled to produce another sweetener called ‘igbalo’ (Oluba *et al*., 2008). The largest producers of egusi seed are West and Central Africa, but with limited statistics. Egusi is not only valuable for local consumption, but also as export commodity to sell to people who have emigrated from Africa to other continents (Van der Vossen *et al*., 2004).

Egusi melon is produced in abundance in Southwest, Southeast and Central parts of Nigeria. It is an important food crop in many sub-Saharan African countries. In Nigeria, it is cultivated as an increasingly important cash crop. Egusi is easy to grow in Nigeria's warm climate during the beginning of the rainy season and harvested at the onset of the dry season (Van der Vossen *et al*., 2004; Brisibe *et al*., 2011).

C. citrullus originated from the western Kalahari region of Namibia and Botswana, where it still exists in the wild in a diversity of forms together with other *Citrullus* species. The most common egusi has fruits that are generally bitter and mainly sought for their seeds, which is the probable ancestor of egusi. Presently, people in Namibia and Botswana still harvest most of their seeds from the wild, but some landraces have been selected specifically for their oil-rich seed (Van der Vossen *et al*., 2004).

The largest producers of egusi seed are West and Central Africa, but with limited statistics. The world production of egusi seed in 2002 was reported as 576,000 tonnes from 608,000 ha (FAO, 2003). Egusi production in Nigeria amounted to 347,000 tons from 361,000 ha, Cameroon produced 57,000 tons, Sudan 46,000 tons, Congo 40,000 tons, Central African Republic 23,000 tonnes and Chad 20,000 tonnes (FAO, 2003). Outside Africa, China is an important producer with a production of 25,000 tonnes. An estimated 5000-7000 tons is traded from Nigeria to other West African countries. Sudan exports about 27,000 tons, mainly to Arab countries; however, these quantities fluctuate strongly yearly (FAO, 2003; Van der Vossen *et al*., 2004).

Generally in Nigeria, there are two major types of egusi that comes to the mind of the people when egusi is mentioned. There has been controversy in the nomenclature of these commonly known egusi types. However, *Colocynthis citrullus* L. appears to be more generally accepted scientific name for the two well-known egusi types (Bara and serewe) and hence the name refers.

The two major seed types are medium sized, and can be differentiated by the presence or absence of a seed edge. The two major types are referred to as 'bara' (yellow with prominent thick seed edge which is either black or white in colour) and 'serewe' (yellow all through without pronounced seed edge) in Yoruba dialect (Kehinde, 2011; Bankole and Joda, 2004; Van der Vossen *et al*., 2004; Bankole *et al*., 2005). The other four are close relatives of egusi (Egunjobi and Adebisi, 2004) which are used for cooking just like the two major/common types. So far these close relatives of egusi are characterized based on the seed type, size and seed coat colour (Ayodele and Salami, 2006; Chiejina, 2006; Achigan-Dako *et al*., 2008) as summarized in Table 1.

The small seeds designated 'N' have uniform yellow colour, while large seeds designated 'E' have white edges. 'E' and 'N' are morphotypes of the 'Serewe' and 'Bara' respectively (Ayodele and Salami, 2006). The medium sized type is classified as *C. citrullus*, the large seeds, that is, 'E' is classified as *C. vulgaris* while the small seeds, i.e. 'N' are classified as *C. lanatus* (Thunb).

Table 1: Different egusi types from South Western States of Nigeria and their description

S/N	Local	Scientific name	Seed type	Seed Size	Seed coat colour
1	Bara	*C. citrullus,*	thick edge (black/white)	Medium size	Yellow/brown
2	Serewe	*Colocynthis citrullus,*	with no prominent white edge	Medium	Yellow with thin white edge
3	N (Wewe)	*Colocynthis lanatus*	Uniformly yellow	Small	Yellow
4	Bojuri	*Colocynthis vulgaris*	Thick seed coat	Large	Light brown
5	Igbaa	*Cucumeropsis mannii*	with brown patch at the seed base	Large	Yellow with brown patch at the seed base
6	Itoo	*Not yet determined*	Uniformly white	Large	White

The seeds of *C. vulgaris* are the largest in size followed by those of *C. citrullus* and the least are those of *C. lanatus*. *C. lanatus* is less than 1/6 the size of *C. vulgaris* and about ¼ that of *C. citrullus* (Chiejina, 2006). *Cucumeropsis mannii* Naudin (syn. *Cucumeropsis edulis* (Hook.f.) Cogn.), said to be the true egusi is also used as egusi (Achigan-Dako *et al*., 2008). However, the production of *C. mannii* is strongly declining nowadays and is being continuously replaced by other egusi species; this could be attributed to the long cropping cycle of this species which covers seven to eight months (Egunjobi and Adebisi, 2004).

Plate 1. Different types of egusi with their corresponding kernels and seeds from different states of Nigeria.
Only Bara and serewe (*Colocynthis citrullus*) are technically called Egusi melon. Bojuri (Colocynthis vulgaris) is also commonly called egusi. N (Wewe) (Colocynthis lanatus) is commonly called Water melon From left Bara from Niger, Wewe from Adamawa, Serewe from Nasarawa, Itoo from Oyo, Bojuri from Kebbi, Igbaa from Oyo,

In the course of research, as many as six different types of seed forms used for the purpose as the two common seed types were discovered. All belonging to the Cucurbitaceae family and are all oil producing. There were six different types of egusi kernels (bojuri from Kebbi, itoo from Oyo, serewe from Nasarawa, igbaa from Oyo, bara from Niger and wewe from Adamawa) sold in Nigerian markets (Plate 1). However, the "bara" and "serewe" types were the most common types of egusi found in Nigeria.

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Profitaility and Factors affecting the Performance of Oil Palm Processors in South West, Nigeria

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ABSTRACT

This study evaluated the profitability and determined factors affecting the performance of oil palm processor in South West, Nigeria. Primary data were collected from two hundred and seventy-five (275) oil palm processors with the aid of structured validated questionnaire through a multi-stage sampling procedure. The data collected were analyzed using Seemingly Unrelated Regression Equation (SURE) and Budgetary Technique. The result revealed that the gross margin and profit of ₦498,534.6 and ₦357,367.9 respectively indicated that oil palm processing business was profitable. The Return on Investment (ROI) value of 1.63 showed that the processors had better performance. SURE, analysis showed experience and household size to be positively and significantly associated with profit while age, depreciation cost, labour cost and transportation cost showed inverse relationship with profit. On the other hand, education and experience showed positive and significant association with return on investment (ROI) while age, household size, depreciation, labour cost and transportation cost had a negative relationship with ROI. It is therefore, recommended that there should be policies which focus on education of processors that will promote performance in the oil palm processing business and extension training services that will enhance the processors experience in order to have a better performance.

INTRODUCTION

Agriculture is an important tool for economic advancement of any developing country like Nigeria. It allows the sustainability of the economy if impart in right direction and appropriate tools are utilized in the processing of agricultural produce. According to Agwu *et al*. (2017) **a**gricultural development along the value chain paves way to poverty alleviation through provision of job opportunities and comfortable lives for millions of people. Nigeria is an agrarian country and agriculture is the backbone of its economy during the colonial and pre-colonial period. The potential of palm oil as the most promising product for the Nigerian agricultural sector and industry encourages and enhances the involvement of both men and women in its processing (Raney *et al*., 2011**)**. Palm oil processing forms major source of income and employment to a large proportion amongst the poor rural population in Nigeria, especially in Southwest (Olagunju, 2008).

Palm oil is very important as its serve as an income generator for processors in Nigeria. In most cases it is women who are in charge of processing the oil palm fruits into palm oil and selling the product in the local and even international markets. The lack of proper scaling of locally fabricated milling technology adversely affects the extraction rate and volume of palm oil production. Ukpabi (2004), stated that the success or failure of palm oil processing depends largely upon how labour and other resources are efficiently used and that an efficient processing technology increases quality and quantity of palm oil available for consumption. Agboola (1993) and Omoti (2001) added that for the processing techniques to be termed efficient, they should satisfy the need of meeting both growth and sustainability goals in the industry. In contribution, Jalami *et al.,* (2000) advocated that oil palm processors should embrace well integrated capital intensive, high volume and high extraction rate in the processing method in order to encourage high transformation of palm oil industry in the country. According to Inyiama *et al*., (2011), several efforts are being made by researchers to involve the ideal palm fruit processing machine in processing.

It is believed that oil palm processing could be more rewarding if the palm fruits is processed into palm oil instead of selling as fruits. Though, the method of processing is tedious, the gains from the products (palm oil, palm kernel and fibers) compensate the processor for the labour (Ukpabi, 2004; Ini-mfon *et al*., 2013)

There is dearth of information on past works on profitability and factors affecting performance of oil palm processors. There are few detailed studies (Omoti, 2001; Omoti, 2004; Olagunju, 2008) on palm oil processing that have relevance to the subject examined in this work. However, it would be wrong to continue to rely on past results for present decisions and policies since natural and socio-economic factors e.g. weather parameters, farmers' potential and ability to manage resources under emerging technologies which influence input output relationship change overtime (Ojemade, 2008).

Due to the reawaken curiosity in oil palm in recent years, it is necessary to evaluate the cost and returns on oil palm processing and also analyze the factors affecting the performance of the oil palm processors. This will help to improve food security and livelihood. Therefore, the objectives of this paper were to evaluate the cost and returns of oil palm processors and also determine the factors influencing the performance of the oil palm processors.

METHODOLOGY

This study was carried out in Southwest geopolitical Zone of Nigeria, which lies between latitude 6^o to the North and 4^o to the South. It is marked by longitude 4^o to the West and 6^0 to the East. It covers a land area of about 114,271 kilometres square representing 12% of the country's land mass. The total population is about 27,581,992 and more than 96% of the population is Yoruba (NPC, 2006). The Zone comprises six (6) States: Oyo, Osun, Ogun, Ondo, Ekiti and Lagos. It is bounded in the North by Kogi and Kwara states, in the East by Edo and Delta states, in the South by the Atlantic Ocean and in the West by the Republic of Benin.

The climate is tropical and characterized by bi-modal rainfall pattern. The raining season, commonly referred to as the cropping season starts from late March and ends in October every year. This is followed by a short break, then the dry season, starting from November to early March. The mean annual rainfall ranges from 800 mm in the derived savannah zone to 1500mm in the rainforest zone, while the mean annual temperature varies from 21.1ºC to 31.1ºC. The vegetation is mostly rainforest. Agriculture is the main occupation of the people and the notable food crops cultivated annually include: cassava, maize, cowpea, rice, sorghum, millet, yam, and banana, while the cash crops: are cocoa, oil palm, rubber, coffee, kola nut among others.

The study adopted a multi-stage sampling procedure. The first stage involved purposive selection of Ondo and Ekiti States out of the six States in Southwest, Nigeria, based on the predominance of oil palm processing enterprises. The second stage involved purposive selection of four (4) Local Governments Areas (LGAs) based on concentration of oil palm processing enterprise from each State. The LGAs were, Okitipupa, Irele, Akure North and Ifedore in Ondo State and Gbonyi, Ise, Emure and Ikere in Ekiti State. The Third stage involved purposive selection of four (4) oil palm dominated processing communities from each LGA., namely: Ominla, Ayeka, Lepa, Iju-Odo(Okitipupa), Ijosu, Ajagba, Ode-Iyasan, Ruwahe (Irele), Ogbese, Oke-odo, Iju, Agopanu (Akure north), Abaoyo, Ajagboto, Okoyelori, agbasa (Ifedore), Emure, Eporo, Igbo-oge, Akeye (Emure), Ogbese, Obada, Afolu , Ekemode (Ise), Aisegba Ode, Iluomoba, Agbado Ekiti (Gboyin), Para, Okeosin, Anoye, Agbado Oyo (Ikere), 10 respondents were randomly selected from each community. This gives a total sample size of 320 oil palm processors but only 275 was valid for the analysis of this study.

Primary data was used for this study. The primary data was collected through Personal interviews and the use of well-structured questionnaire to obtain information from the oil palm processors. The information that was generated through the questionnaire included variables on the socio-economic characteristics of oil palm processors (age, sex, educational level, processing experience, household size, source of capital,), input used (water, number of bunches processed/year, labour, machine/equipment, diesel) the output of production (litres of oil palm produced/metric tonnes).

Budgetary Technique

The budgetary technique was used to determine the cost and returns from oil palm processing. Costs and returns were estimated on output within a production season of 2019. Variable costs include: costs of FFB, labour, picking, slicing, threshing, sieving, boiling, digestion, offloading, water, firewood, rubber, basket, transportation, annual rent, and diesel, while the fixed cost include: costs of equipment such as digester, broiler, presser, axe, cutlass, wheelbarrow, separator, filter, basin, shovel and cracker.

The equations of the budgetary analysis are stated as:

$$GM = TR - TVC \quad \ldots\ldots(1)$$

$$NI = TR - TCP = GM - TFC \quad \ldots\ldots(2)$$

$$ROI = TR/TCP \quad \ldots\ldots(3)$$

$$ESR = TFC/TVC \quad \ldots\ldots(4)$$

$$GR = TC/TR \quad \ldots\ldots(5)$$

Where; TR = Total revenue, P= Price (Naira), Q = Quantity of oil palm (litre), TCP = Total cost of processing, TVC = Total variable cost, TFC = Total fixed cost, GM= Gross margin, NI = Net income, ROI =Return on Investment, ESR = Expenses Structure Ratio, and GR = Gross Ratio

Seemingly Unrelated Regression Equation (SURE)

Seemingly Unrelated Regression Equation (SURE) was used to determine factors affecting the performance of the processors. (Objective 2). As specified below

$$Y_i^* = f(X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8, \varepsilon_i) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(6)$$

Where ,*Y = the dependent variables and they are Y_a, and Y_b for profit, and ROI respectively, X_1 = Age, X_2 = Education, X_3 = Household size, X_4 = Marital status, X_5 = depreciation on fixed input, X_6 = Experience, X_7 = Labour cost, X_8 = Transportation cost, ε_i = error term and $\beta_{1\text{-}8}$ are estimated parameters.

RESULTS AND DISCUSSION

Costs and Returns Analysis

Table 1 revealed the budgetary analysis of the oil palm processors, which comprises total revenue and total cost of processing. The total cost of processing comprises total fixed cost and total variable cost. The total fixed cost (TFC) incurred by the processors was ₦141,166.61. The TFC values for the respondents formed 24.70% of the total cost of processing (TCP) respectively. The mean TFC was ₦141,166.6. The mean total variable cost (TVC) incurred by the processors was ₦430,433.06, as the values accounted for 75.30% of the total cost of processing. The total revenue was 928,967.63. the profits were ₦357,367.9. The mean gross margin and profit of ₦498,534.6 and ₦357,367.9 indicates that oil palm processing business is a profitable business. ROI value for processors was 1.63 meaning that processors had better performance. The value of Expense Structure Ratio (ESR) of 0.33 indicated that the variable cost incurred in the business is greater than money expended on fixed cost by 67%. The value of gross ratio (0.62) also revealed that total revenue accrued from oil palm processing is greater than the total cost expended in the course of the business by 38%. All these profitability measures confirmed and reiterated the profitability of oil palm processing.

Table 1: Results of Cost and Returns of Oil Palm Processing

ITEMS	MEAN	PERCENTAGE
Annual rent on land	103,529.87	18.11
Picking cost	69,777.66	12.21
Slicing cost	5,971.16	1.04
Threshing cost	4,725.83	0.83
Sieving cost	5,331.90	0.93
Boiling cost	6,746.77	1.18
Digestion cost	5,224.60	0.91
Offloading cost	8,169.03	1.43
Water cost	11,454.49	2.00
Firewood cost	6,525.89	1.14
Kerosene cost	10,078.18	1.76
Basket cost	4,501.27	0.79
Transportation cost	92,522.60	16.19
Diesel cost	6,099.32	1.07
FFB Cost	27,060.07	4.73
Total labour cost	57,425.27	10.05
Total Variable Cost	430,433.06	75.30
Depreciation cost on equipment	141,166.61	24.70
Total Fixed Cost	141,166.61	24.70
TCP	571,594.67	
TR	928,967.63	
GM	498,534.57	
Profit	357,367.97	
ROI	1.63	
ESR	0.33	
GR	0.62	

Source: Computed from Field Survey Data, 2019

Determinant of Factors Affecting the Performance of Oil Palm Processors

The results of the Seemingly Unrelated Regression Equation (SURE) in determining factors affecting the performance of oil palm processors is presented in Table 2. Generally, the coefficients of variables that were positive with the regressands (i.e. profit and Return on Investment) imply that increase in the value of any of these variables will increase and have upward relationship with the dependent variable and vice-versa.

RESULTS

The chi-square statistics showed 55.87 for profit, 44.43 for ROI and are significant at 1% level. This implies that the null hypothesis of the restrictions of valid homogeneity and symmetry for the system equations were accepted. According to Table 2, the result showed that coefficients of age of the processors was negatively related with the regressands and were all statistically significant at 1% level. This implies that older oil palm processors had their profit reduced by ₦99.18. The ROI value revealed that for every naira invested by the processors, ₦0.06 was lost from the oil palm processing business

The coefficient of year of education was negatively related with profit. Also, the result showed that education is statistically significant at most 10% level with ROI. This implies that advancement in educational attainment will cause a positive increase in the value of ROI of which 10kobo will be earned on every naira expended in the enterprise.

Coefficients of Household size had positive relationship with profit and statistically significant at 5% level. The results showed that a unit increase in the number of family size will increase profit by ₦288.69.

The coefficient of experience was positive and statistically significant with the dependent variables. The results showed that an increase in the years of experience will increase profit by ₦125.77. The ROI value revealed that for every naira expended by the processors, ₦0.07 was gained from the oil palm processing enterprise.

Coefficient of labour cost showed a negative association with profit and ROI. This implies that for every naira expended on labour the ROI is reduced by 0.0000056.

The transportation cost of processing oil palm had a negative coefficient with the dependent variables and statistically significant at 5% and 1% level ($P < 0.05$) for profit and ROI respectively. This is an indication that a naira increase in the transportation cost will reduce profit by ₦0.76.

Table 2: Results of Seemingly Unrelated Regression Model on Factors Affecting performance of the processors

Variables	Profit		ROI	
Age	-99.18***	(0.000)	-0.06***	(0.000)
Education	-34.36	(0.669)	0.10*	(0.063)
Household	288.69**	(0.012)	0.08	(0.337)
Marital status	-151.78	(0.922)	-0.15	(0.889)
Depreciation	-3.59***	(0.005)	-9.11e-06	(0.303)
Experience	125.77***	(0.002)	0.07**	(0.020)
Labour cost	-0.53	(0.268)	-5.56e-06*	(0.094)
Transport cost	-0.76**	(0.003)	-6.86e06***	(0.004)
Constant	367.02	(0.295)	4.08	(0.096)
Chi-square	55.87***		44.43***	

Source: Computed from Field Survey, 2019. Significant at***1%, **5%, *10%

CONCLUSION AND RECOMMENDATIONS

The study evaluated the costs and returns on oil palm processing and factors affecting the performance of oil palm processors in Southwest, Nigeria. The analysis of the cost and return indicated that oil palm processing business is profitable. The Return on Investment (ROI) showed that the processors had better performance. SURE, analysis showed that experience, household size, age, depreciation, and transportation cost were significantly associated with profit. On the other hand, education, experience, age, depreciation, labour cost and transportation cost were significantly associated with return on investment (ROI). Hence these variables affect the performance (profit and ROI) of oil palm processors.

Therefore, there should be policies which focus on education of processors that will promote performance in the oil palm processing business. Government should set up extension training services that will enhance the processors experience and the adoption of labour saving processing techniques in order to have a better performance. Government should also provide good feeder road to enable processors transport the palm fruits for processing at a minimal cost.

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Application of Agricultural Extension Principles to Sustainable Agricultural Practices in Rural Communities of Enugu State, Nigeria

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K E Y W O R D S

Agricultual practices,
Enugu State,
Extension,
Principle,
Sustainable agriculture

A B S T R A C T

This paper explored agricultural extension principles that can be applied to sustainable agricultural practices in rural communities of Enugu State, Nigeria. The paper was based on a desk review of available relevant literature. Information was accessed through a web search, Google scholar, open-accessed journals, magazines, periodicals, newspapers, books, and reports. The paper identified sustainable agricultural practices such as ridging/mound making, planting of trees/grasses, terracing, and local water harvesting and examined agricultural extension principles that can be applied to them namely: the principle of starting at the level of farmers, the principle of education of farmers, the principle of cooperative work and principle of constant evaluation. Also, the following challenges were described: inadequate number of extension personnel, poor farmer-extension-research interaction, and low level of education between extension agents and farmers. The paper concluded that agricultural extension principles can be applied to sustainable agricultural practices and recommended recruitment of more educated extension personnel to close the huge gap between extension farmer ratio in the state and constant training of extension workers.

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INTRODUCTION

Humans and the environment are interconnected as man exploits the environment to meet man's need for food, clothing, and shelter. Agriculture is an age-long activity undertaken by the early man who went about scavenging for wild crops and animals with little or no threat to the natural ecosystem (Maude, 2020). Today, agriculture has grown in all ramifications through innovative research and other developmental efforts by relevant stakeholders to meet the food needs of the growing population. The world's population has been increasing from 32 million people in 1950 to about 600m people today and is expected to grow to about 8.5 billion by 2030 (The Guardian, 2022). Efforts are geared towards producing enough food on the same mass of land for the teeming population using diverse scientific methods and agricultural technologies such as pesticides, inorganic fertilizer application, and herbicides which pose a threat to the environment and natural ecosystem and hence, the need for sustainable practices to ensure that the needs of today's generation are met without compromising the ability of future generations to meet their own needs (Anani *et al.*,2020; Feenstra *et al*., 2021).

Sustainable practices can facilitate the protection of the natural ecosystem, increase yield, improve food security, and reduce rural poverty. Nigeria is far from reaching its Sustainable Development Goals (SDGs) come 2030, but sustainable agricultural practices can contribute to achieving goals of no poverty, zero hunger, responsible consumption and production, climate action, and sustainable cities and communities (Tajudeen and Taiwo, 2018; Otekunrin *et al.*,2019). Sustainable agricultural practices are those practices that allow for more efficient use of natural resources, mitigate the impacts of unsustainable agriculture practices on the natural ecosystem, and strengthen capacity for adaptation to climate change and variability in Enugu State, Nigeria (Pineiro *et al*., 2020). The people of Enugu State are predominantly farmers. The state is divided into three agricultural zones: Enugu North, West, and East. The major crops grown in the state include cassava, maize, plantain, cocoyam, rice, yam, groundnut, and vegetables like fluted pumpkin, Amaranthus, garden eggs, and okra. Enugu State has had its hit of climate change as increasing temperatures, rising temperatures, and changes in rainfall patterns. This climate change has affected smallholder farmers' productivity since they depend on agriculture for their income, food, and livelihood and are the producers and suppliers of food consumed in urban areas and other neighboring states (Obetta *et al.*, 2020). According to the findings of Ozor (2010), who investigated the difficulties in adaptation to climate change by farmers in Enugu state, he posited that the most difficult challenge faced by farmers in adaptation to climate change impacts in the state is unsustainable agricultural practices. Also, a recent study carried out by Nwobodo *et al.* (2022), who investigated determinants of ruminant farmers' use of sustainable production practices for climate change adaptation and mitigation in Enugu State, revealed that there is a significant positive correlation between the knowledge level of farmers and their use of sustainable practices. This implies that an improved knowledge level of sustainable agricultural practices through extension education can enhance their resilience to the increasing impacts of climate change.

Therefore, the role of extension agents in raising farmers' awareness and knowledge level towards sustainable agricultural practices cannot be over-emphasized. Since the extension is the vehicle through which agricultural technologies are disseminated to rural farmers, it, therefore, becomes pertinent that the extension agents are thoroughly furnished with adequate knowledge and possess skills needed to carry out extension work and to achieve this goal, the extension agents have to understand the principles of extension work and its application in other to successfully help farmers change their skill, attitude, and knowledge as regards to sustainable agricultural practices (Olorunfemi *et al*., 2020). Over the years, agricultural extension as an academic discipline has developed a set of principles for carrying out its operations. These principles are the bedrock of success in agricultural extension work, but there is still a gap in its application in sustainable agricultural practices in Nigeria. Probably, this may be a result of poorly-trained extension personnel. Therefore, the paper examined the application of agriculture extension principles to sustainable agriculture in rural communities of Enugu State, Nigeria. Specifically, the paper sought to: examine sustainable agricultural practices in rural communities; identify the agricultural extension principles that can be applied to sustainable agriculture practices and challenges in the application of agriculture extension principles to sustainable agriculture practices in Enugu State.

METHODOLOGY

The paper was based on a desk review of available relevant literature. Data were mainly through a web search, google scholar, open-accessed journals, magazines, periodicals, newspapers, books.

RESULTS AND DISCUSSION

Sustainable agricultural practices in rural communities

According to David (2017), through decades of science and practice, the following farming practices have proven effective in achieving sustainability when used in combination: crop rotation, mixed cropping, planting cover crops and perennials, reducing or eliminating tillage, applying integrated pest management (IPM), integrating livestock and crops, adopting sustainable agroforestry practices and managing whole systems and landscapes**.** These practices focus on the soil by keeping farm soils protected and teeming with living organisms can solve many of the problems associated with industrial agriculture. Healthy, living soil promotes healthy crops, holds water like a sponge, prevents pollution, and helps ensure that farmers and their communities can thrive. Furthermore, in the traditional setting, some of the sustainable agricultural practices in rural communities of Enugu State include:

i. **Ridging/mound making:** ridges and mounds are made across the flow of runoff water removing sand/nutrients from the soil.
ii. **Planting trees/grasses**: trees and grasses are planted annually on erosion-prone soil to reduce the impact of rainfall on the soil. Certain trees and grasses are required for this operation
iii. **Local water harvesting**: the building of modern houses with long roofing sheets has exacerbated the deterioration of agricultural land for farming. Harvesting rainwater using pots, jerry cans, and tanks of various shapes and sizes has contributed a lot to conserving water for agricultural purposes. In some instances, a water reservoir is constructed of concrete cement to collect rainwater.
iv. **Community water reservoir**: in some farming communities, large pits are dung at strategic locations to collect runoff water from different parts of the community. The water collected may be purified and used for various operations during water scarcity.
v. **Terracing**: this is the practice of cutting part of the hills or mountains and planting crops/flowers to control erosion. It does the dual purpose of beautifying the environment and producing food and fiber for the sustenance of livelihood and industry.

Social capital: this is the use of traditional rules and regulations to control crop and animal production. This includes levies /fines imposed on harvesting certain crops on unauthorized periods, roaming domestic animals and setting fire to bushes/forests, and seizure of straying animals.

Agricultural extension principles that can be applied to sustainable agriculture practices

Recently, global environmental issues have received attention due to the increase in global problems relating to climate change due to human and agricultural activities. The effects of these human activities due to high urbanization and population explosion have led to an increase in greenhouse gases such as carbon dioxide, nitrous oxide, and methane resulting in rising sea levels, high temperatures, and increasing rainfall. The need to produce food, clothing, and shelter to cater to the needs of the increasing human population characterized by the exploitation of natural resources has led to severe environmental degradation (Adu *et al.,* 2020). The IPCCS (2019) report indicates that 70% of the world's landscape has been affected by human activities and agricultural intensification, and these activities caused land degradation. Data from World Bank indicates crop production increased by 240% between 1961 and 2017. Agricultural forestry, and other related land use activities together emit about 13% carbon dioxide, 44% of methane, and 82% of nitrous oxide during the 2002-2016 period representing a total of 23% of all greenhouse emissions caused by anthropogenic factors (Shukla *et al.,* 2019),

To cub the negative impacts of climate change which threatens our environment there is a need for climate action through land use related adaptation and mitigation options by farmers. This implies that there is a need for extension to educate farmers on agricultural sustainability practices to reduce or eliminate farming activities that increase the concentration of carbon dioxide and methane in our environment by creating awareness using agricultural extension systems (Adu *et al.,* 2022). Hence, it becomes very expedient for extension personnel to understand the underlining principles of extension work to effectively disseminate agricultural sustainability technology to farmers. Agricultural extension principles are guidelines for the conduct of extension work, and these principles are the bedrock upon which extension service rests. These principles may not be suitable for all communities because of differences in culture, nature, and other socio-economic variables. The implication is that extension principles should be applied based on prior knowledge of farmers' socio-cultural and environmental conditions. One way to ensure the application of agricultural extension principles to sustainable agriculture practices is to involve the agricultural extension agencies. Agricultural extension as a discipline has all it takes to mainstream rural farmers into sustainable agriculture practices. Understanding these principles by extension personnel is germane and effective in convincing farmers to use sustainable agricultural practices (RUFORUM, 2023). The following agricultural extension principles can be applied to sustainable practices.

Extension workers base their program of sustainable agriculture practices on the present level of farmers and their environment. They consider the level of knowledge, interest, and degree of readiness by trying to understand the social structure, habits, traditional attitude, and economic status of the people and society to put into practical use to convince farmers to embark on sustainable agricultural practices with the aim of achieving a desired change. Also, extension workers ensure the application of sustainable agricultural practices by developing the interest of farmers and their need to use sustainable agriculture practices to protect the environment and our future generations. The extension agent raises sustainable practices awareness through planning, educating and training of farmers on such practices through sustainable education programmes. Therefore, farmers' interests and needs are easily directed to the use of sustainable agricultural practices in producing food and preserving the environment (Anthony *et al*., 2019).

Through educational means, extension workers assist farmers to take the right decisions in the use of sustainable agricultural practices. According to Enwelu *et al.* (2016), extension workers are well-qualified to educate farmers on sustainable agricultural practices. They possess the expertise and are viewed as a credible information source by farmers. As educators, they possess good communication and teaching skills which enables them to excel in their work.

One way extension workers can convince farmers to apply sustainable agricultural practices is by engaging them in cooperative work. Both extension workers, farmers and their families, and other major stakeholders must be involved in the planning of sustainable agricultural programmes. Furthermore, when they are involved in all stages of the project, they personalize the project leading to sustainable outcomes. Similarly, when a sustainable agricultural project is undertaken as a cooperative venture, farmers and their family members are likely to apply sustainable agricultural practices in their daily farming operations (Chromal, 2016).

Application of agricultural extension principles to sustainable agricultural practices can be enhanced by constant periodic evaluation of sustainable ongoing and implemented programmes. When extension workers evaluate sustainable agricultural practices constantly in light of existing and changing environmental conditions, farmers can easily appreciate whether the objectives of the agricultural project are being achieved or not. Also, as an intermediary between researchers and farmers, the facts extension workers acquire from researchers are exchanged with farmers while farmers' challenges are conveyed to researchers by extension workers. Therefore, extension workers convey facts about sustainable agricultural practices to farmers thereby improving their application of sustainable agricultural practices (Okoedo-Okojie and Edeoghon, 2017).

Challenges in the application of agricultural extension principles to sustainable agricultural practices in Enugu State

Agricultural extension over the years has proven to be inevitable in the delivery of adequate scientific research information to farmers and feeding researchers with challenges undermining farmers' quest for an improved standard of living. Agricultural extension as a discipline performs multitasks in any area of development. According to Ijeoma and Adesope (2015), the roles of extension today go beyond technology transfer and training of farmers but include assisting farmers to form groups, addressing public interest issues in rural areas such as resource conservation, agricultural production, food safety, nutrition, youth development, and partnering with a broad range of service providers and other agencies. In the process of carrying out these enormous responsibilities, the following challenges are hampering agricultural extension service delivery in Nigeria.

Inadequate number of extension personnel

The number of extension workers is not enough to perform their front-line activities in the agricultural sector in Nigeria. Apantaku, *et al*. (2016), reported that inadequate extension personnel negatively affect effective agricultural extension service delivery. If the number of extension workers is not enough to carry out its traditional roles, it becomes an uphill task to engage in a sustainable agricultural project.

Poor farmer-extension-research interaction

The level of interaction of extension workers with researchers determines the quality of innovative products available to farmers. The interaction of researchers with extension workers enables them to have a good understanding of the sustainable agricultural practices to be passed to farmers. The World Bank era with Agricultural Development Programme (ADP) ensures regular technical fortnightly training meetings of researchers with extension workers to update them with the latest agricultural technologies for onward transfer to farmers. Presently, such interactions no longer exist or are performed on a skeletal basis. This is in line with the findings of Aderinto *et al*. (2017), who found out that irregular extension visits is the most severe constraints to extension service delivery.

Low level of education between extension agents and farmers

The low level of education of farmers and extension agents hampers the dissemination and assimilation of extension principles. Until now, few extension agents in rural communities have gotten degree certificates in agricultural extension while most farmers are still grappling with low educational challenges. This scenario can delay the application of sustainable agricultural practices by extension workers and farmers in the sense that extension workers may not be fully grounded in the principles they are passing on to farmers (Ajani and Onwubuya, 2013).

CONCLUSION AND RECOMMENDATIONS

Sustainable agricultural practices identified in rural communities of Enugu State were: ridging/mound making, planting of trees/grasses, terracing, and local water harvesting. Agricultural extension principles that can be applied to sustainable agricultural practices include the principle of starting at the level of farmers, the principle of cooperative work, and others. However, the major challenges affecting the application of agricultural principles to sustainable agricultural practices were the inadequate number of extension personnel, among others. The paper concluded that agricultural extension principles can be applied to sustainable agricultural practices and recommended the following: inclusion of sustainable agricultural practices in agricultural extension mandate, periodic evaluation of sustainable agricultural programmes and constant training of extension workers.

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Perceived Attitude of Farmers towards the use of ICT Tools among small holder rice farmers in Southeast, Nigeria

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K E Y W O R D S

Attitude,
ICT use,
Rice farmers,
Southeast

A B S T R A C T

The study examined Perceived Attitude of Farmers towards the use of ICT Tools among small holder rice farmers in Southeast, Nigeria. Specifically, it described socioeconomic characteristics of smallholder rice farmers, ascertained the perceived attitude of farmers towards the use of ICT tools, analyzed the extent of use ICT tools and determined the significant relationship between smallholder rice farmers and their level of use of ICT. Data were collected with a structured questionnaire from 476 randomly selected smallholder rice farmers. Collected data were analyzed using descriptive statistics of mean threshold and Spearman Bivariate correlation. The result showed that smallholder rice farmers were relatively young because rice farming is physically demanding and old age can pose a problem to the cultural operations. It was discovered that the use of ICT tools is a source of motivation to both the extension agents and farmers' thereby promoting learning, and ICT can be said to propel knowledge. The result on relationship between farmers and their level of use of ICT shows that a unit increase in farmer's attitude will increase the level of use of ICT tools/format by 0.237 unit. It was recommended that government and other relevant bodies should ensure that ICT facilities are installed in rural communities, necessary trainings should be slated for smallholder rice farmers on the use of ICT tools/format by appropriate authorities to boost their confidence and reliance on ICT.

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INTRODUCTION

Agriculture in Africa has a massive social and economic footprint; more than 60% of the population of Sub-Saharan Africa are smallholder farmers, and about 23% of Sub-Saharan Gross Domestic Product (GDP) comes from agriculture (Goedde, Ombaka and Pais, 2019). These smallholder farmers engage in different livestock and crops production including rice.

Rice is the primary staple food for most of the populace in the region, especially the rural area, with about 6% of global rice consumption, Africa accounts for about 4% of the world production making the continent the second largest consuming and producing region (Abdul-Gafar and Yu, 2016). According to Uba (2003 as cited by Gbughemobi, 2021), about 70% of Nigeria feeds on rice, while 30% of their cereal-based diets are also from rice.

Information Communication Technology (ICT) can be broadly described as the means through which information can be communicated for individual, societal and collective growth of a nation (Ogunyemi, 2010 and Gbughemobi, Nkamigbo and Meludu, 2021). Information and Communication Technologies (ICTs) are becoming more and more important in connecting farmers and providing information. ICTs help keep young people involved in agriculture.

MATERIALS AND METHOD

The study was conducted in Southeast Nigeria. It is one of the six geopolitical zones of Nigeria. The zone comprises of Imo, Anambra, Abia, Enugu and Ebonyi States. The region is located between latitude $5^{o}45^{'}00^{''}$N and longitude $8^{o}30^{'}00^{''}$E. It is bordered by the Niger River in the west and has an administrative and cultural border with the Northern region of Nigeria. The eastern boundary lies between the border of Nigeria and Cameroon and the Southern coast is along the Gulf of Guinea. The total surface area of the region was approximately 76000 square kilometers (29,400sq m).The region has three types of vegetation namely mangrove swamps, tropical rainforest and guinea savannah.

Population of the study

The population of the study consists of all the rice farmers in Southeastern and a multi-stage sampling technique was adopted to select 480 respondents within States in Southeast, Nigeria. The first stage involved purposive selection of three states with a high concentration of rice farmers in Southeast, Nigeria; (Anambra, Enugu and Ebonyi States). The second stage also involved the purposive selection of two (2) agricultural zones from each State making it a total of six (6) zones. The third stage involved the purposive selection of two (2) Local Governments Areas (LGAs) from each of the six agricultural zones based on high concentration of rice farmers making it a total of twelve (12). The fourth stage involved the random selection of two (2) communities from each local government making it a total of twenty-four (24) communities. Finally, twenty (20) rice farmers were randomly selected from each of the 24 communities, giving a total sample of four hundred and eighty (480) respondents for the study. The data were analyzed using descriptive statistics which included chart, frequency, percentage and mean, mean threshold of 5 Point Likert Scale and Spearman bivariate correlation of non-parametric tools.

Instrument for data collection

Qualitative and quantitative methods were used to collect data from the respondents. Qualitative data were collected using focus group discussion (FGD), this is used to gather first-hand observation of the process of individuals discussing issues. It captures real-life data in the social environment (Babbie, 2001). It brings out aspects of the topic that were not anticipated by the researcher. FGD also helped generate interview topics, questionnaire items and can help the researcher judge the adequacy of the analysis and help in the interpretation of the situation (McQueen and Knussen, 2002). Quantitative data would also be collected using a well-structured questionnaire. The researcher employed the use of Survey CTO which is a powerful, reliable and easy to use survey platform that allows one to at least transport and process data for academic research.

Measurement of variables

Independent variable: The independent variables for the study include:

The personal and enterprise characteristics of the respondent measured as follows:
Sex: Sex was measured as male = 1 or female = 0

Age: Age was measured as the actual age (in years)

Marital status: single =1, married = 2, widow (er) = 3, separated = 4

Educational qualification: Years spent in school.

Years of farming experience: The respondents were asked to state the total number of years they have spent in farming.

Dependent variables: A dependent variable is a variable whose variation depends on that of another, it is gotten as a result of the manipulation of another variable. For the purpose of this study, the dependent variable is:

RESULTS AND DISCUSSION

Socio-economic characteristics of smallholder rice Farmers

Table 1 shows that majority (61.3%) of the rice farmers in the study area were male. This implies that rice farming in the study area were male dominated, this could be owing to the fact that rice farming is masculine in nature. . This agrees with findings of Efah and Kuye (2015) which records that there were more male farmers than females in their study area. The study found out that the greater proportion (31.9%) of the farmers were within the age bracket of 31 – 40 years with the mean age of 37.93. The implication is that rice farmers in the area are still in their active farm age. At the mean age, the use of ICT is expected to be high. In support of this Ajah and Ajah (2014) opines that rice farming is physically demanding and old age can pose a problem to the cultural operations. Majority (65.5%) of the farmers were married, thus, married people dominated rice farming in the area. This agrees with the findings of Agbolahor, Obunyela and Adebowale (2012). This agrees with Kuye and Ettah (2015) who states that relevance of the literacy level of a farmer is relevant to farm productivity and production efficiency. The result revealed that farmers have spent 9 years (9.28) in rice farming in the study area.

Table 1: Socio-economic characteristics of Rice Farmers (n = 476)

Variable	Frequency	Percentage (%)	Mean
Sex:			
Male	292	61.3	
Female	184	38.7	
Age (years):			
≤ 20	16	3.4	
21 – 30	130	27.3	37.93
31 – 40	152	31.9	
41 – 50	124	26.0	
51 – 60	48	10.1	
61 and above	6	1.3	
Marital status			
Single	140	29.4	
Married	312	65.5	
Divorced	24	5.0	
Level of education			
Primary school uncompleted	46	9.7	
Primary school	111	23.3	
W.A.S.C/NECO	156	32.8	10.29
HND/B.Sc.	121	25.4	
M.Sc./PhD	42	8.8	
Farming experience (years):			
≤ 5	239	50.2	
6 -10	94	19.7	
11 – 15	27	5.7	9.28
16 – 20	67	14.1	
21 and above	49	10.3	
Primary occupation			
Farming	307	64.5	
Trading	26	5.5	
Art and craft	35	7.3	
Civil servant	108	22.7	
Secondary occupation			
Farming	84	17.7	
Trading	298	62.6	
Art and craft	74	15.5	
Civil servant	20	4.2	
Household size			
≤ 5	257	54.0	
6 – 10	186	39.1	5.56
11 and above	33	6.9	
Farm size (plot)			
<= 10	230	48.3	
11 – 20	73	15.3	
21 – 30	48	10.1	11.42
31 and above	125	26.3	
Annual income from rice (₦)			
≤ 50,000	11	2.3	
50,001 - 150,000	92	19.3	
150,001 - 250,000	48	10.1	426,499.76
250,001 - 350,000	57	12.0	
350,001 and above	268	56.3	

Source: Field Survey Data, 2021.

Attitude of Farmers towards the use of ICT Tools

The farmers' attitude to ICT which influenced their thought is presented in Table 2. The information was subjected to a 5 Point Likert Scale to determine the mean threshold of farmer's attitude. The mean threshold of less than 3.0 was said to have a poor attitude while the mean threshold of 3.0 and above was said to have a satisfactory attitude to the use of ICT. Thus, based on the 11 items of farmer's attitude captured, 6 had a mean threshold of 3.0 and were; ICT tools help in sourcing of rice innovation. ICT tools can be used to circulate innovations easily, ICT training for extension agents will enhance their ability to use ICT tools for sourcing and dissemination of innovation. The use of ICT tools is a source of motivation to both the extension agents and farmers' thereby promoting learning, and ICT can be said to propel knowledge. The cluster mean of 3.01 shows that the general farmers have a satisfactory attitude to ICT, while the standard deviation of 0.96 shows that their individual responses varied enough to make logical conclusions. This finding is in line with Kabir (2015) but contradicts the findings of Ajayi, Alabi and Okalawon (2018) who noted that farmers have a negative attitude towards ICT use.

Table 2: The Distribution of Farmers' Attitude to the Thought about the Use of ICT Tools

S/ N.	Variables	SDA	DA	SWA	A	SA	Mean	Std. Dev.	Decision
1.	ICT tools help in sourcing of rice innovation	31	115	103	140	87	3.29	1.20	Favorable attitude
2.	The use of ICT tools can be used to circulate innovations easily	12	126	157	122	59	3.19	1.04	Favorable attitude
3.	ICT training for extension agents will enhance their ability to use ICT tools for sourcing and dissemination of innovation	6	88	190	153	39	3.28	0.90	Favorable attitude
4.	ICT tools is a means of getting relevant material and new findings	0	103	92	208	73	3.53	1.00	Favorable attitude
5.	The use of ICT tools is a source of motivation to both the extension agents and farmers thereby promoting learning	6	87	175	166	42	3.32	0.91	Favorable attitude
6.	Sourcing for innovation through the ICT tools is not helpful to the extension agent	7	290	99	69	11	2.55	0.84	Unfavourable attitude
7.	Large numbers of farmers fail to adopt innovation disseminated by extension agent due to the use of ICT tool	23	197	114	99	43	2.88	1.08	Unfavourable attitude
8.	ICT tools coverage is readily available in areas extension agent disseminates	15	229	169	63	0	2.59	0.76	Unfavourable attitude
9.	Getting relevant materials for learning purpose cannot be achieved via ICT tools	42	251	133	39	11	2.42	0.85	Unfavourable attitude
10.	The use of ICT tools as a means of communication between extension agent does not promote learning	55	274	81	34	32	2.4	1.01	Unfavourable attitude
11.	ICT can be said to propel knowledge	0	66	123	189	98	3.67	0.96	Favorable attitude
	Cluster Mean						3.01	0.96	Satisfactory

Source: Field Survey Data, 2021.

Extent of Use of ICT Tools/Format

The extent of use of ICTs tools/format in the study area is presented in Table 3. The information on extent of use of ICT tools/format was captured and subjected to a 5 Point Likert Scale to determine the mean threshold of extent of use of ICT tools/format. The mean threshold of less than 3.0 shows that farmers did not agree to the use of ICT tools/format, while the mean threshold of 3.0 and above shows the farmers agree to the use of ICT tools/format. Thus, based on the 24 items of extent of use of ICT tools/format captured, only 5 had a mean threshold of 3.0 and they were; Radio set, Television, Mobile Phone, Short Message Services, and On-line Magazines. The cluster mean of 2.10 shows that the majority of the farmers did not use the ICT tools/format in the area, while the standard deviation of 0.93 shows that their individual responses varied enough to make logical conclusions since ICT tools are not readily available and are poorly accessible to the farmers in the study area, the usage is expected to be equally poor. Again most of these ICT tools are sophisticated and require expertise in operation and usage, this will equally discourage the farmers from its usage and adoption.

Table 3: Distribution of the Extent of Usage of these ICT Tools/Format

S/N	Tools	Never Use	Rarely	Moderately	Often	Very often	Mean	Decision
1.	Radio set	10	0	7	102	357	4.67	Use
2.	Television	10	24	71	178	193	4.09	Use
3.	Facebook	144	36	153	83	60	2.75	Not use
4.	Mobile Phone	11	23	17	242	183	4.18	Use
5.	Short Message Services	69	28	272	43	64	3.01	Use
6.	CD-ROM	282	67	60	47	20	1.86	Not use
7.	Video CD Player	262	72	89	40	13	1.89	Not use
8.	Computer System	210	63	69	70	64	2.4	Not use
9.	Internet	161	72	120	59	64	2.57	Not use
10.	Digital Camera	351	63	13	36	13	1.52	Not use
11.	YouTube	292	89	51	31	13	1.71	Not use
12.	Multimedia Projector	383	46	28	13	6	1.35	Not use
13.	Digital video Disk (DVD)	317	80	53	20	6	1.57	Not use
14.	E-mail	408	61	7	0	0	1.16	Not use
15.	On-line Magazines	127	21	50	160	118	3.25	Use
16.	GPRS	219	81	66	76	34	2.21	Not use
17.	Whatsapp	388	34	34	20	0	1.34	Not use
18.	Instagram	413	16	28	19	0	1.27	Not use
19.	Video Conferencing	433	36	7	0	0	1.11	Not use
20.	Tele Conferencing	283	91	18	64	20	1.84	Not use
21.	Robots	399	63	7	7	0	1.21	Not use
22.	Twitter	230	234	12	0	0	1.11	Not use
23.	Likee (Online Video posting)	400	62	7	7	0	1.2	Not use
24.	Mixler (Online Radio)	425	51	0	0	0	1.11	Not use
	Cluster mean					2.10	0.93	Not use

Source: Field Survey Data, 2021.

Relationship between the farmer attitude and their level of use of ICT.

The relationship between farmer's attitude and the level of use of ICT tools/format is in Table 4. The Spearman Bivariate correlation for non-parametric tool conducted to test the correlation between farmer's attitude and the level of use of ICT tools/format in the study area was positive and significant at two tailed probability level of 0.01. This implies that a unit increase in farmer's attitude will increase the level of use of ICT tools/format by 0.237 unit. This justifies that the null hypothesis five was rejected. Thus, farmers' attitude correlate with the level of use of ICT tools/format. This result is in line with the findings of Sylem and Raj (2015).

Table 4. Relationship between the farmer attitude and their level of use of ICT Table 4: (n = 476)

			Attitude	Use
Spearman's rho	Attitude	Correlation Coefficient	1.000	0.237**
		Sig. (2-tailed)	.	0.000
		N	476	476
	Use	Correlation Coefficient	0.237**	1.000
		Sig. (2-tailed)	0.000	.
		N	476	476

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

Source: Field Survey Data, 2021. Bivariate correlation matrix

CONCLUSION AND RECOMMENDATIONS

Findings on socioeconomic characteristics showed that the majority (61.3%) of the farmers are male; the mean age of the farmers was found to be 38 years while the majority (65.5%) of them was married. The mean years spent in formal education was 10 years. The mean farming experience was 9 years, while the mean household size, farm size and annual income from rice was 5 persons, 11.42 plots, and ₦426,499.76 respectively. Also, the primary occupation was majorly (64.5%) farmers. The farmer's attitude to ICT which influenced their thought were; ICT tools help in sourcing of rice innovation, The use of ICT tools can be used to circulate innovations easily, ICT training for extension agents will enhance their ability to use ICT tools for sourcing and dissemination of innovation, The use of ICT tools is a source of motivation to both the extension agents and farmers thereby promoting learning, and ICT can be said to propel knowledge. Also, ICT tools were not readily available and were poorly accessible to the farmers in the study area. Most of these ICT tools require expertise in operation and usage and thus equally discouraged farmers from its use and adoption.

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Factors Affecting Shea Nut Collectors' and Shea Butter Producers' Willingness to Adopt Improved Shea Seedling in North-Central Nigeria

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ABSTRACT

Shea tree is highly valued because of its fat containing fruits. Traditionally North-central rural people are involved in shea nut collection and shea butter production. It is an economic venture for rural households. It present sound investment options for eradicating poverty. Despite the economic value of shea tree, is still growing in the wild and the improved shea seedling is yet to be adopted by farmers. Willingness is a major stage in adoption, and the adoption of improved technologies is one of the greatest challenges facing farmers. This study therefore examined, the factors affecting willingness of the shea nut collectors and shea butter producers to adopt improved shea seedlings. A three-stage sampling technique was used to select 200 respondents drawn from 5 Local Government Areas across two states of Kwara and Niger. And the total of 150 respondents was used for the study; consisting 78 shea nut collectors and 72 shea butter producers. Descriptive statistics and logit regression were used for data analysis. Majority (70%) were not aware of improved shea seedling while (72.67%) were willing to adopt the improved shea seedlings. Household size, gender, educational level, marital status, land ownership, membership of association, annual income, input cost, occupation, experience and extension contacts were the significant factors affecting the shea nut collectors and shea butter producers willingness to adopt improved seedlings ($p<0.05$). Government and all stakeholders need to collaborate with NIFOR in the area of mass production of improve shea seedlings to curtail the reliance on the natural regeneration of shea.

INTRODUCTION

Shea tree is an indigenous butter oil producing plant. In Nigeria, shea is mostly found in the savannah province. Nigeria has the largest shea tree density and is the largest producer of shea butter in the world (FAO, 2013). Studies on the density importance of shea trees in the derived Guinea savanna, northern Guinea savanna, Sudan and Sahel savanna, showed Kwara, Oyo and Niger to have the largest shea tree densities (Odebiyi *et al*., 2004). Shea tree belongs to the family *sapotaceae,* with subspecies (*Vitellaria nilotica* and *V. paradoxa*). It can fruit for several years once productive. And fruiting is seasonal (Abdul-Moomin *et al.*, 2016). Shea tree can attain optimum yields of up to 45 kilogrammes per annum. Some shea tree can also produce between 50 and 100kg per annum. The kernels of shea fruits are made up of 40 to 50% oil (Bup *et al*., 2013). Shea tree has a unique resource for societal development. Traditionally, North-central rural people are involved in shea activities. These activities are economic ventures that serve as valuable income source for rural households in the region. Shea fruit collectors are the first group along the shea value chain and they are sometimes referred to as nut traders. They collect the shea fruits during the onset of raining season and process it to dry kernels. Shea butter producers add value to the kernels to produce shea butter which is the most important component of the shea tree. Shea nut and butter production activities represent a major source of income to mostly women and children in North-central Nigeria (Garba and Sanni 2015) and (Olife, 2013).

Shea tree are vulnerable species, mainly growing in the wild, this make their domestication very crucial. The tree, because of the resourcefulness of its nuts in tropical Africa was recommended among other trees as product of priority (FAO, 1991). Therefore the need to diversify the economy through mass production of improved shea seedlings. Recognizing the potentials of domesticating shea nut tree would lead to an increase in the establishment of sustainable shea resources for greater benefits in the near future. The fact remains that the shea nut collectors and shea butter producers still depend on the wild products. Despite the several socioeconomic benefits from the sale of shea nut/butter and its impact on poverty reduction, the improved shea seedling is yet to be fully adopted.

There is therefore the need to assess the respondents' willingness to adopt improved shea seedling. Willingness is a major stage in adoption, and the adoption of improved technologies is one of the greatest challenges facing the agricultural sector in Nigeria (Adekoya and Tologborse, 2005). Several studies have investigated the socio-economic factors affecting willingness to adopt new technologies. Recommendations from these studies have always been constrained by the fact that farmers' adoption behavior is highly diverse and influenced by a complex set of technology and site-specific socioeconomic variables (Buyinza and Naagula 2009). This research work however examined farmer's willingness to adopt improved shea tree seedlings and examine those factors that may influence the adoption behaviour of the target respondents. Besides, this relevant information will present clear evidence of areas that require private and government intervention with respect to the actor's adoption of improved shea seedlings for the purpose of increasing shea tree density.

METHODOLOGY

Study Area

North-central is vital for the study due to the abundant concentration of shea trees (Olaoye, 2011). Kwara and Niger State specifically formed the study area; they have the largest density of shea tree and shea nut activities in North-central Nigeria (Odebiyi, *et al.*, 2004, Suleiman 2008).

Sampling Procedure

Three-stage sampling technique was used. The first stage involved the purposive selection of 2 states in North-central Nigeria, specifically Kwara and Niger. The second stage involved the purposive selection of 5 Local Government Areas (LGAs) across the 41 LGAs in the two states. The third stage involved the selection of 40 respondents through random sampling technique in each LGA. The study sampled the total of 200 respondents randomly selected from 2 LGAs in Kwara State and 3 LGAs in Niger State. The responses from 150 respondents were used for data analysis, consisting 78 shea nut collectors and 72 shea butter producers.

Method of Data Collection and Analytical Techniques

The study was based on primary data elicited with the aid of well structured questionnaire. Both descriptive and inferential statistics was employed to analyze the data from the field survey.

Logit Model

The logit of a number "p" being either 0 or 1 is given by the formula:

$$\ln\left(\frac{P_i}{1-P_i}\right) = \sum_{k=0}^{k=n} \beta_k X_{ik} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

It is the equation used to estimate the coefficients same as:

$$\ln\left(\frac{P_i}{1-P_i}\right) = \beta_0 + \beta_1 X_1 + \ldots\ldots + \beta_k X_k \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where Pi can be specified as: $P(Z=1/X_1, X_2 \ldots\ldots\ldots X_k) = f(\beta_0 + \beta_1 X_1 + \beta_2 X_2 \ldots\ldots + \beta_k X_k) \ldots\ldots\ldots (3)$ *or*

Where β1-βk are the parameters to be estimated, Pr (Zi = 1) represent the dependent variable as the willingness of the shea nut collectors and shea butter producers to adopt improved shea seedling; taking the value of 1 as willing to adopt and 0 for otherwise. The model was specified implicitly as Pr (Zj = 1) = f ($X_{1i}, X_{2i}, X_{3i}, X_{4i}, X_{5i}, X_{6i}, X_{7i}, X_{8i}, X_9, d_{1i}, d_{2i}, d_{3i}, d_{4i}, d_{5i}, d_{6i}$)e…………….....(6)

Where Z= Zj and = willingness and j = category of actors. Then Z1: shea nut collectors and Z2: shea butter producers.

Z_1= Willingness to adopt improved shea seedling by shea nut collectors
X_1 = household size (number of persons in the household)
X_2= educational level (number)
X_3 = experience (years)
X_4 = number of seedling willing to plant (number)
X_5 = Amount willing to pay (₦)
X_6 = annual income (₦)
X_7 = extension contacts (number of times)
X_8= credit obtained (₦)
d_1 = marital status (married = 1, otherwise = 0)
d_2 = sex (dummy: 1 for male and 0 for otherwise)
d_3 = awareness of shea tree conservation (aware 1, otherwise 0)
d_4= land ownership (own 1, otherwise 0)

d_5 = membership of association (member = 1, otherwise = 0)
d_6= occupation (shea nut collector 1, 0 for otherwise)
Z_2= Willingness to adopt improved shea seedling by shea butter producers
X_1 = household size (number of persons in the household)
X_2 = educational level (number)
X_3 = experience (years)
X_4 = number of seedling willing to plant (number)
X_5 = Amount willing to pay (₦)
X_6 = annual income (₦)
X_9 = input cost (years)
d_1 = marital status (married = 1, otherwise = 0)
d_2 = sex (dummy: 1 for male and 0 for otherwise)
d_3 = awareness of shea tree conservation (aware 1, otherwise 0)
d_4= land ownership (own 1, otherwise 0)
d_5 = membership of association (member = 1, otherwise = 0)
d_6= occupation (shea butter producer 1, 0 for otherwise)

Table 1: Socioeconomic Characteristics of Shea Nut Collectors and Shea Butter Producers

Variables	Categories	% Pooled (n=150)
Age	20-30	14.69
	31-40	34.94
	41-50	30.72
	51-60	14.16
	>60	5.5
Experience	1- 10	31.79
	11-20	41.83
	21-30	18.16
	> 30	8.23
Education	None	1.34
	Non-formal	51.71
	Primary	27.89
	Secondary	15.81
	Tertiary	3.26
Household size	1-5	4.54
	6-10	29.92
	11-15	46.05
	16-20	14.69
	21-25	1.98
	>30	3.48
Gender	Male	3.26
	Female	96.74
Marital status	Married	82.05
	Otherwise	17.95
Other occupation	None	8.09
	Civil servant	2.57
	Trading	51.93
	Artisan	6.47
	Money lending	3.21
	Farming	27.73
Credit access		65.44
Membership of Association		68.38
Extension service		54.82

Field Survey 2019

As shown in Table 1, the modal age of the respondents' fall within the age range of 31-40 and 41-50 years and this constitutes 65.66% of the respondents. The mean age was found to be 42 years. This could be an indication that majority of the shea nut collectors and shea butter producers are still within the productive age limit during which they can fully and efficiently engage in all forms of productive labour. The mean years of experience of the respondents was found to be 17. Experience in the shea nut collecting and shea butter producing activities could define the productivity of the individual actor; which is expected to impact positively on the production activities. The results showed that the majority of the respondents (51.71%) had no formal education. Illiteracy could be a barrier for respondents to accept innovation. The mean household size of the respondents was 13 people. Larger family sizes are more likely to adopt technology due to availability of sufficient and cheap labour and could be regarded as an added advantage for increased productivity. The study reported 96.74% respondents to be women and majority (82.05 %) were married. This is because marriage is also regarded as mark of honour and dignity which is held in high esteem in the study area. The result further revealed that the respondents (51.93%) and (27.73%) have their other income sources from trading and farming respectively. Income from other sources could boost the productive capital of the respondents and stimulate willingness to adopt improved technology. Majority of the respondents (65.44%) had access to credit that are mainly from friends, relatives and local cooperatives. Credit is a strong tool that is capable of enhancing the productive capacity of the respondents. The result revealed that 68.38% of respondents belong to an association. Being a member of association presents a great opportunity in shearing useful information through training to improve strategies in production activities. Majority (54.82%) of the respondents had access to extension services. Extension service is relevant in terms of transferring results of scientific research. Progress in the adoption of improved shea seedling could be achieved through extension services.

Table 2: Awareness and Willingness to Adopt Improved Shea Seedlings

Actors	Shea butter producers (n=72)		Shea nut collectors (n=78)		Pooled (n=150)	
Variable	Freq.	%	Freq.	%	Freq.	%
Aware	35	48.61	10	12.82	45	30.00
Not aware	37	51.39	68	87.18	105	70.00
Willing	57	79.17	52	66.67	109	72.67
Not willing	15	20.83	26	33.33	41	27.33

Field Survey 2019

The analysis in Table 2 showed that 30% of the shea nut collectors and shea butter producers are aware of improved shea seedlings. Further analysis revealed that more than 20% out of this were from Niger State. This could be attributed to their proximity to Nigerian Institute for Oil-palm Research (NIFOR) improved shea tree seedlings substation in Bida Niger State. Awareness is the first stage in adoption process and involves the individual learning of the existence of technological innovation (Ekong, 2003). More so, 72.67% indicated their willingness to adopt and plant improved shea seedlings. The high turnout of those willing to adopt could be attributed to the fact that the shea nut collectors and shea butter producers have been in the processing activities for a long period and the benefit they derive is undisputable.

Table 3: Shea Nut Collector's Willingness to Adopt Improved Shea Seedlings

Variables	Odds Ratio	Std. Err.	z	P>|z|	dy/dx
Total household size (X_1)	0.64514	0.09808	2.88	0.004**	0.10849
Educational level (X_2)	1.00154	0.0013897	1.11	0.269	0.00038
Experience (X_3)	0.1414	0.06942	2.17	0.03**	0.03274
No. of seedlings wln (X_4)	1.0028	0.00215	1.31	0.191	0.00069
Amount wilng to py. (X_5)	0.99702	0.00269	1.11	0.268	0.00074
Annual income (X_6)	3.14777	1.65891	2.18	0.03**	0.2838486
Extension contacts (X_7)	0.20797	0.16353	2.00	0.046**	0.3597
Credit obtained (X_8)	1.11261	0.09577	1.24	0.215	0.02641
Marital status (d_1)	1.41171	0.9239544	0.53	0.598	0.08539
Gender (d_2)	0.50947	0.36867	0.93	0.351	0.16677
Awareness (d_3)	0.9556	0.07831	0.55	0.579	0.01124
Land ownership (d_4)	0.21516	0.15268	2.17	0.03**	0.35738
Membership of asso. (d_5)	244.535	420.26	3.2	0.001**	0.87547
Occupation (d_6)	0.03158	0.04537	2.41	0.016**	0.67527

Number of obs = 78
LR $chi^2(14)$ = 36.52

Prob > chi^2 = 0.0009
Pseudo R^2 = 0.3384
Log likelihood = -35.701688
Marginal effects after logit y = Pr(willingnesstoadopt) (predict) = .54963586

Field Survey 2019 (*) dy/dx is for discrete change of dummy variable from 0 to 1 Note: $*$ = significant at $P \leq 0.05$.

Table 4: Shea Butter Producer's Willingness to Adopt Improved Shea Seedlings

Variabl s	Odds Ratio	Std. Err.		P |z|	dy/dx
No. of seedling willn. (X_4)	0.99937	0.00237	0.27	0.791	0.00014
Amount willing to pay (X_5)	0.998625	0.00234	0.59	0.558	0.06098
Total household (X_1)	0 .7526749	0.10056	2.13	0.033**	0.15396
Educational level (X_2)	2.04908	2.82427	1.67	0.031**	0.284479
Annual Income (X_6)	0 .9073347	0.52915	0.17	0.868	0.02087
Input cost (X_9)	0.99985	6.4E-05	2.36	0.018**	0.324000
Experience (X_3)	1.07247	0.07124	1.05	0.292	0.015015
Marital status (d_1)	0.18887	0.155991	2.02	0.044**	0.32063
Gender (d_8)	1.18674	0.8493793	0.24	0.811	0.03633
Awareness (d_3)	1.0981	0.7238646	0.14	0.887	0.02008
Land ownership (d_4)	0.19865	0.1550067	2.07	0.038**	0.32063
Membship. of asso.(d_5)	7.530824	7.54393	2.02	0.044**	0.43481
Occupation (d_6)	0.13826	0.13781	1.99	0.047**	0.3673

Number of obs = 72

LR $chi^2(13) = 27.02$

Prob > $chi^{2 =}$ 0.0285

Pseudo $R^{2 =}$ = 0.2784

Log likelihood = 35.024421

Field Survey 2019 (*) dy/dx is for discrete change of dummy variable from 0 to 1

The logistic regression of the shea nut collector's and shea butter producer's willingness to adopt improved shea seedlings is presented in Table 3 and 4. A pseudo R2 of 0.3384 and 0.2784 were obtained for shea nut collectors and shea butter producers respectively. A Pseudo R2 between 0.2 and 0.4 is considered highly satisfactory; therefore the dependents variables fit the models. The Chi-square statistic of 36.52 (p 0.0009) and 27.02 (p 0.0285) obtained for shea nut collectors and shea butter producers respectively were all less than 0.1 i.e. ($p < 0.1$) and were all significant, this shows that all the models were statistically significant and are of good fit for the analysis. More so, the chi-square significant values indicate a high interaction effect between the response variable and combination of explanatory variables included in the models. In order to find the effect of predictor variables on the willingness of the respondents to adopt improved shea seedlings, marginal effect (dy/dx) was generated. The marginal effects of shea collector's and shea butter producer's willingness to adopt were well predicted at 55% and 69% respectively, with the rate of willingness to plant improved shea tree higher amongst shea butter producers.

The variables of household size, annual income, extension contacts, experience, land ownership, membership of association and occupation for shea nut collectors were all significant at 5%. This implies that they all have positive influence on the respondent's willingness to adopt improved shea seedlings. For household, it implies that any unit increase in the number of persons, the log of odds of the respondent's willingness to adopt improved shea seedlings will increase by 0.0980818. The marginal effect of 0.1084928 of household size implies that there is 11% greater chance of adopting improved shea seedlings as the family members increase. It's logical to say larger family sizes are more likely to adopt technology due to availability of sufficient and cheap labor. Furthermore, other variables like annual income, extension contacts, experience, land ownership, membership of association and occupation were all positive and significant at 5%, which implies that a unit increase in annual income, extension contacts, experience, land ownership, membership association and occupation will increase their corresponding log of odds by 1.658907, 0.1635257, 0.1526755, 420.3595 and 0.0453732 respectively. And their corresponding marginal effects by 0.2838486, 0.324000, 0.0327383, 0.35738, 0.8754748 and 0.6752731 respectively, which will indicate 28%, 36%, 32%, 36%, 87% and 67% greater chance of shea nut collector's adopting improved shea seedling as the variables increase. The implication is this, as annual income increases from shea collection activities, the tendency to embrace shea tree planting will increase. Poverty reduces a household's willingness and ability to invest in agricultural technologies (Holden and Shiferaw 2002). Willingness to plant by implication will increase with the increase number of extension visits through sharing of information and training on adopting new ideas. Collector's years of experience would have given them the evidence of the relevant of conserving the shea tree resources. Experience is however expected to have a positive effect on willingness to adopt improved shea seedlings. Availability of land and land size will definitely arouse the shea nut collector's willingness to adopt, the bigger the land the more willing to plant shea tree or respondents with bigger land are more likely to be willing. Membership of association could be an avenue for shearing useful information about improved technologies, this however could be a stimulating factor for the shea nut collectors to adopt improved seedling. Membership of social organization refers to social participation in organization which enhances interaction and exposes rural dwellers to information about improved technologies, therefore high success rates in adoption of improved technology when they work in groups. Furthermore, as shea collectors remain in their activities of shea nut collection as the main occupation, the chance of adopting improved shea seedling will increase knowing the relevant of their activities over time.

More so, the variables of household size, educational level, input cost, marital status, land ownership, membership of association and occupation were all significant at 5% for shea butter producers. This implies that they have positive influence on the producer's willingness to adopt improved shea seedling. It implies that a unit increase in any of the variable will increase the corresponding log of odds by 0.7526749, 2.049078, 0.9998489, 0.1888719, 0.1986537, 7.530824 and 0.1382569 respectively. And the marginal effects of 0.153959, 0.2844786, 0.324000, 0.4348072 and 0.3672988 of household size, educational level, input cost, membership of association and occupation of shea butter producers will indicate 15%, 28%, 33%, 43% and 36% greater chance of adopting improved shea seedling respectively. While the log of odds of marital status and land ownership will increase by 0.18887 and 0.19865 respectively and their corresponding marginal effects of 0.3206314 and 0.3206314 will indicates 32% greater chance of the shea butter producer's to be willing to adopt improved shea seedlings. Level of education being significant confirmed the apriori expectation of a positive relationship between willingness to adopt and education. A higher level of education is expected to increase respondents' ability to acquire, process and use information to their advantage.

Summary of the Major Findings

The mean age of the respondents is an indication that majority of the shea nut collectors and shea butter producers are still within productive age limit, with considerable practical years of experience in production activities and large household sizes. Thirty percent of the shea nut collectors and shea butter producers are aware of improved shea seedling and majority indicated their willingness to adopt. Household size, gender, educational level, marital status, land ownership, membership of association, annual income, input cost, occupation, experience and extension contacts have positive effects on the willingness to adopt improved shea seedlings among the shea butter producers and shea nut collectors ($p<0.05$).

CONCLUSION AND RECOMMENDATIONS

Based on the research findings, majority were not aware of improved shea seedlings but were found to be willing to adopt the improved shea seedling. The willingness to adopt improved shea seedlings among the shea nut collectors and shea butter producers were influenced by their socioeconomic characteristics and production resources. The willingness of the respondents to adopt improved shea seedlings need to be addressed for the sustainability of shea tree in North-central Nigeria.

In order to sustain the use of shea tree, the study recommends the provision hybrid of shea with a reduced gestation period to actors that are willing to adopt. This will encourage shea tree planting and curtail the reliance on natural regeneration of shea. Government and all stakeholders need to collaborate with NIFOR in the area of mass production of improved shea seedlings at affordable rate. Extension contacts, land ownership and input cost should be taken into consideration when developing strategies to stimulate willingness to adopt shea seedlings.

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Profitability of Fish Farming in Awka, Anambra State, Nigeria

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K E Y W O R D S

Awka,
Cost,
Fish farming,
Net Farm Income,
Profitability,
Revenue

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A B S T R A C T

The study examined the profitability of fish farming in Awka, Anambra State, Nigeria. A simple random sampling technique was used to select six Fish farms namely Housetully fish farm, Ujundu fish farm, Ausco fish farm, Chizzy fish farm, and Chuksagro farm in the Awka metropolis. Structured questionnaires were used to collect data from the respondents. Descriptive statistics and net farm income analysis were used to analyze the data obtained. The result of the socio-economic analysis showed that all the respondents (100%) were males and all had formal tertiary education. Also, 50% of the respondents were mostly between the ages of 31- 40 years and had an average of 7 years of experience in the fish farming business. The majority of the respondents derived their capital largely from personal savings and spent an average total expenditure of N610,242.2 and earned an average gross income of N1,100,000. Gross margin analysis revealed a gross margin of N579,096 with a net farm income of N599,758 implying that for every 1N invested in the fish farm business, there was a return of N1.11. This study concluded that fish production in the study area is highly profitable. The study also revealed that despite the high profitability of the fish farm business in Awka, the fish farmers still face some serious problems such as high feed costs, fish diseases, high cost of fish seeds, high labor costs, and inadequate power supply. It is suggested that government involvement in fish farming will support these practicing fish farmers and also encourage unemployed youths to engage in fish farming.

INTRODUCTION

Fish farming is known to have significantly boosted Nigeria's economic development over the past 20 years (Olanrewaju, *et al.*, 2022). Fish farming currently contributes 3.5% to Nigeria's gross national product (GNP) and accounts for 0.2% of the total world fish supply (Umaru *et al*., 2021). Nigeria's annual demand for fish presently is about 1.4 million tonnes, while domestic production is about 780,000 tonnes. This shows that there is a large gap between supply and demand and this has led Nigeria to import fish annually (Nwiro, 2012). To cover this deficit, Nigeria needs at least one million tons of fish to feed its population annually (Sambo *et al.*, 2021). Nyong, (2021) asserted that there is a need to increase production and reduce fish imports into the country to enable economic growth in Nigeria. Therefore, more efforts in fish farming are needed to bridge the gap between fish supply and demand in Nigeria.

Fish farming is a branch of aquaculture that involves the domestication and rearing of various species of fish. This practice allows for the feeding, breeding, growing, and harvesting of fish in a well-planned and controlled environment (Sambo *et al*., 2021). According to Agyakwah *et al*., (2020), there is a wide range of fish farming options including raising fish in earthen ponds, concrete ponds, plastic tanks, and other water holding facilities. However, the popular and simple techniques are fish production in an earthen and concrete pond, which are the basic units of fish farming practices worldwide (Ekine *et al*., 2019). The major species cultured in Nigeria include tilapia, catfish, and carp. However, the African catfish species (*Clarias gariepinus*) is the most widely accepted and highly valued fish with a higher survival rate (Nyong, 2021). Fish farming has great potential to increase the nutritional needs of the Nigerian populace. FAO, (2012) reported that fish contribute more than 60% of the world's protein supply, especially in developing countries. Fish farming also has the prospect of creating employment, generating income for the urban population, improving the socio-economic status of the farmer as well as generating foreign exchange (Oluwasola and Ige, 2015).

The farming of catfish accounts for more than half of the total national aquaculture production. However, a decline in production has been observed since 2015 and it has been reported that some catfish farmers are abandoning the fish farming business (Olanrewaju, *et al*., 2022). Despite the potential of fish farming to improve livelihoods in rural communities of Nigeria, it has not been fully explored as a poverty reduction strategy. Ikeogu *et al* (2020) reported that inadequate quality fish seed for stocking, poor extension services, lack of fish farmers' cooperative societies, poor infrastructural facilities, poor funding by the government, and high cost of fish feed are some of the major constraints facing aquaculture industry in Nigeria. These problems reduce the income potential of farmers, which in turn affects their livelihoods.

With this in mind, the Nigerian government has devised several developmental projects with a greater focus on fish farming to address the problem of low fish production and also to create a conducive environment for fish farming in Nigeria (Nyong, 2021). Government support for fish production is essential, but the most important aspect is the management of fish farms by farmers to maintain production capacity. To fully understand the economics of fish farms in Nigeria, it is necessary to obtain information on the cost and return generated by the fish farms which will guide financial planners on net farm income analysis to increase fish production and fish farm performance towards profitability (Asuquo *et al*., 20018). Therefore, this study aims to evaluate the profitability of fish farming and fish production constraints in Awka, Anambra State.

MATERIALS AND METHODOLOGY

Sampling Procedure

A simple random sampling technique was used to select six fish farms in the Awka metropolitan area namely Housetully fish farm, Ujundu fish farm, Ausco fish farm,Chizzy fish farm, and farm. A structured questionnaire was used to collect data from the respondents. The survey collected information on socioeconomic characteristics, costs and incomes of fish farming, and production constraints faced by farmers.

Net Farm Income Analysis

Net farm income (NFI) analysis was used to determine the profitability of the fish farming business in the Awka metropolis, Anambra State. It is the difference between the gross farm income and the total costs of production. A positive NFI indicates a profitable business while a negative NFI indicates an unprofitable one.

(1) Net farm income was determined as follows: NFI = GM-TFC
TFC = total fixed cost
(2) Gross margin analysis was calculated as GM =TR-TVC
Where GM = gross margin (N)
TR= total revenue (N) = Price (P) x Quantity of fish (Q)
TVC = total variable cost (N)
(3) RCI = GM/TVC
Where RCI = return on capital invested

The 3 Points Likert Rating Scale Technique

The 3 points Likert scale rating was used to assess the constraints of fish production in the study area which has three response categories as follows: very severe (VS) =3; Severe (S)=2; and not severe (NS) =1. The mean score of the three response categories was computed as 3+2+1=6/3=2.0. Any item with a mean score of 2.0 and above was considered a serious constraint while an item that scored less than 2.0 was considered as not a serious constraint to catfish farming in the study area.

Data Analysis

Descriptive statistics such as frequency distribution and percentages were used to determine the socio-economic characteristics of the respondents. Net farm income analysis and gross margin techniques were used to determine the profitability of fish farming in the Awka metropolis, Anambra State.

RESULT

Table 1 showed the socio-economic status of the fish farmers in Awka. All the respondents (100%) were males and all had formal tertiary education. Also, 50% of the respondents were married, mostly between the ages of 31- 40 years, and had an average of 7 years of experience in the fish farming business. 83.3% of the respondents had fish farming as their primary occupation and derived their source of capital from personal savings.

Table 1: Socio-economic characteristics of respondents

Parameters	**Frequency**	**Percentages**
Sex		
Male	6	100
Female	0	0
Total	6	100
Age		
21-30	2	33.33
31-40	3	50.0
41-50	1	16.67
51-60	0	0.0
Total	6	100
Marital status		
Single	3	50
Married	3	50
Separated	0	0
Total	6	100
Level of Education		
No formal education	0	0
Primary education	0	0
Secondary education	0	0
Tertiary education	6	100
Total	6	100
Primary occupation		
Farming	5	83.3
Trading	0	0
Civil servants	0	0
Artisans	0	0
Others	1	16.67
Total	6	100
Farming experience(years)		
<4	1	16.67
5-8	3	50
9-12	2	33.3
More than 12	0	0
Total	6	100
Source of capital		
Personal savings	5	83.3
Relatives and friends	0	0
Cooperative societies	0	0
Bank loan	1	16.67
Total	6	100

Table 2 showed the variable cost involved in fish production in the Awka metropolis which includes fish seed, fish feed, labour, drugs, fuel, transportation, and others. The average value of all the variable costs in the six fish farms was N520,904.

Table 2: Average value of the variable cost of fish production (per batch) in Awka Metropolis

Variable cost	Value (Naira)	
Fish seed (fingerlings)		30,000
Fish feed	340,266	
Labour	81,000	
Drugs	20,133	
Utilities	8,866	
Fuel	3,973	
Transportation	10,000	
		10,000
Miscellaneous	16,666	
Total variable cost		520,904

Table 3 showed the depreciated value of all the fixed costs incurred in the six fish farms in the Awka metropolis which include pond construction, pumping machines, tanks, weighing scale, and land. The average value of all the fixed costs in the six fish farms in Awka was N89.338.2.

Table 3: Average value of fixed assets and their depreciation values

Fixed cost items	Total value (N)	Lifespan (years)	Depreciation (Naira)
Pond construction (10x10ft)	231,333	10	23,133.3
Pumping machines	50,000	15	3,333
Plastic tank (10x10ft)	39,275	10	3,927.5
Weighing scale	20,000	10	2,000
Land (plot)	854,166	30	28,472.2
Total Fixed cost	1,194,772		89,338.2

Table 4 showed the average cost and returns of fish production in the Awka metropolis. The fish farmers spent an average total expenditure of N610,242.2 and earned an average gross income of N1,100,000. Gross margin analysis revealed a gross margin of N579,096 with a net farm income of N599,758 and a return of N1.11 implying that fish farming is profitable in Awka.

Table 4: Average cost and returns of fish production in Awka Metropolis

Items	Average value (N)	
Revenue		
The average quantity of fish sold in kg		1000
Average price per kg		1,100
Total Revenue		1,100,000
Total variable cost.	520,904	
Total depreciated fixed cost		89,338
Total Cost (N).		610,242.2
Gross Margin GM (TR-TVC)		579,096
Net Farm Income NFI (GM-TFC)		599,758
Return on capital invested (RCI) (GM/TVC)		1.11

Table 5 showed the constraints of fish production in the study area using the 3-point Likert scale rating. The major problems identified were high feed costs, fish diseases, high cost of fish seeds, high labor costs, inadequate power supply, and others.

Table 5: Constraints to fish Farming in Awka Metropolis

Constraints	mean	standard deviation
Access to capital	1.33	0.516
Disease problem	2.33*	0.816
High cost of equipment/materials	2*	0.63
Poor infrastructure	2*	0.63
Low harvest of fish	2.33*	0.816
High cost of labor	2*	0.63
Climatic conditions	1.67	1.03
High cost and poor quality of feed and lime	2*	0.63
Inadequate power supply	2*	0.89
Theft/pilfering of fish	1.33	0.816
High cost and poor quality of fish seeds	2.17*	0.983
Pests and diseases infestation	1.5	0.84
Flooding in earthen pond	1.33	0.82
.Lack of adequate land	1.67	0.816
Poor brood stock breed	1.83	0.98
Lack of adequate water	1.33	0.816
Lack of technical know-how	1.67	0.816

Source: Field Survey, 2022.

DISCUSSION

The Socioeconomic characteristics of fish farmers considered in this study included gender, age, level of education, farming experience, primary occupation, and source of capital. Results of the socio-economic analysis of this study presented in Table 1 showed that all the respondents (100%) were males and all had formal tertiary education. Also, 50% of the respondents were mostly between the ages of 31- 40 years and had an average of 7 years of experience in the fish farming business. This study showed that men were the dominant fish farm owners in the Awka metropolis. This could be so because women engage more in fish processing, preservation, and marketing in the study area (Ikeogu, *et al*., 2020). Male predominance in fish production was also reported in Niger state by *Yisa et al*., (2015). The analysis also showed that 50% of the respondents were in the middle and economically active age group (31-40 years) suggesting that training the farmers in fish farming may be effective. This result compares favorably with the finding of Tunde *et al*. (2015). All the respondents (100%) had attained a tertiary level of education as indicated in Table 1. This study agrees with the work of (Umaru *et al.*, 2021) who reported that a higher level of education is necessary for improved farm management and the use of new production technologies. The analysis of the years of experience revealed that 50% of the fish farmers in the study area had an average of 7 years of experience in the fish farming business. This finding is in agreement with the work of Olanrewaju, *et al.* (2022) who stated that the profitability of fish farms is also influenced by farmers' years of experience. Age, level of education, as well as years of experience in the fish farming business, are among the factors that determine the managerial ability of the fish farmers. In fish farming, proper management determines the profitability of aquaculture production (Olanrewaju, *et al.*, 2022).

Table 1 also revealed that the majority of fish farmers have fishing as their primary source of income. This may be a result of the huge capital investments it takes to start up the business which also requires commitment. Results showed that most of the farmers (83.3%) obtained their capital from personal savings. This could be a result of the large interest rate on loans offered by banks, which therefore makes it not feasible for starting the business. The finding is consistent with that of Yisa *et al.* (2015) who found out that the majority of fish farmers in Niger state derived their source of capital from personal savings.

Data on the cost and return generated by the six fish farms were obtained and expressed on average to determine the profitability of the fish farm business in the Awka metropolis. Variable costs (VC) included in the analysis were expenditures on fish seed, fish feed, labour, drugs, utilities, fuel, transportation, and other miscellaneous costs. On the other hand, fixed costs that can be used for more than a production cycle include depreciated value on pond construction, pumping machines, tanks, weighing scale, and land. This study recorded an average variable cost of 520,904, an average fixed cost of 89,338.2, an average total cost of N610,242.2, and an average gross income of N1,100,000 which are all presented in Tables 2, and 3. Gross margin analysis revealed a gross margin of N579,096 with a net farm income of N599,758 implying that for every 1N invested in the fish farm business, there was a return of N1.11. The study revealed positive net return and a high rate of income indicating that fish farming is profitable in the Awka metropolis. This result agrees with that of Umaru *et al*., (2021) who reported a return on capital investment of 1.25 and a positive Net Farm Income indicating that fish farming is profitable in Enugu State. Several studies have shown that fish farming is a profitable business (Sambo *et al*., 2021; Ebukiba and Anthony, 2019; Ekine *et al.*, 2019).

Despite the profitability of the fish farming business in the Awka metropolis, the production level is very low. This study identified all the constraints of fish production faced by the fish farmers in Awka, Anambra State, and the result is presented in Table 5. Fish diseases and low fish harvest are the major problems of fish farming in the study area. An outbreak of diseases in a fish farm reduces overall output leading to low fish production. Other serious constraints affecting the fish farm business in Awka are poor quality of fish seed, high cost of fish feed, high cost of equipment/materials, high cost of labor, poor infrastructure, and inadequate power supply. This may be attributed to the cost of importation of most commercial feeds and fish farm inputs into the country, nonfunctional hatcheries to improve the quality of fish fingerling, and erratic power supply in the Awka metropolis. The findings reported here are similar to that of Yisa, *et al*., (2015).

CONCLUSION

This study concluded that fish production in the study area is highly profitable as a result of positive net returns and a high rate of income. It is also observed that Awka has great potential for fish farming in creating employment, improving the socio-economic characteristics of the fish farmers, and generating income. The study also revealed that despite the high profitability of the fish farm business in Awka, the fish farmers still face some serious problems. It is suggested that government should support these existing fish farmers with subsidized fish farm inputs and also encourage unemployed youths to engage in fish farming.

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Determinants of Agricultural Export and Trade Liberalization in Nigeria

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K E Y W O R D S

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A B S T R A C T

The study estimated short and long run relationships between trade liberalization and agricultural export performance in Nigeria from 1999-2020. Time series analytical were used. Result revealed that, two variables; agricultural import (AIMP) and agricultural degree of openness (ADO) were stationary at levels while others; (ACF, AEXP, EXR and NAP) became stationary at first difference. The short-run and long-run agricultural GDP performance with respect to the macro-economic variables were analysed using the techniques of co-integration and error correction models. Result revealed that,at the long run, coefficients of agricultural export (AEX), agricultural degree of openness (ADO), national agricultural productivity (NAP) and agricultural capital formation (ACF) were positively significant at 1 and 10 percent levels respectively. Agricultural import (AIMP) and exchange rate (EXR) were negative but significant at 1 and 5% respectively. At the short-run, result shows a negative but significant relationship with respect to agricultural capital formation (ACF), agricultural export (AEXP) and exchange rate (EXR. Result revealed negative relationship between national agricultural productivity (NAP), exchange rate (EXR), agricultural import (AIMP), agricultural export (AEXP) and agricultural capital formation (ACF) at one year lagged. With R^2-adjusted of 0.9273 and ECM of -0.6372 implies that, 92.73% variations in Agricultural GDP performance was affected by the independent variables and 63.72 of disequilibrium in the current period may be corrected for in the long-run. The study recommended that, appropriate short- and long-term economic policy instruments should be enforced to stimulate investment and production opportunities in the agricultural sector so as to increase agricultural GDP performance.

INTRODUCTION

Agricultural export trade has received much international attention due to fragile nature of the sector, volatile nature of world prices for agricultural commodities, and to trade distortions induced by major players in various agricultural commodity markets (CBN Annual report, 2016). Exportation is required by any economy to enhance revenue and usher in economic growth and development (World Trade Organization, WTO 2018). Agricultural exports can accelerate a balanced growth in all countries involved if only issues (trade restrictions and distortions) related to the world trade in primary agricultural trade are addressed or drastically reduced. . Liberalization as a process in multilateral trading system has been an issue of debate among researchers and scholars. According to World Bank (2018), liberalization is defined as actions undertaken by states to make trade regimes more neutral and closer to a trade system which is devoid of government intervention. On the one hand, proponents of liberalization have argued that opening up of markets leads to increased trade and competition; thus, making domestic firms to be more productive. On the other hand, opponents of liberalization argue that openness of trade can be detrimental to poor countries as a result of loss of jobs and trade imbalances among other factors (Pennycooke, 2011). Echekoba, Okonkwo and Adigwe, (2015), identified some factors that constitute major problems of trade liberalization to include weak institutions and fiscal and monetary policy indiscipline. Supported by high global commodity prices, exports of agricultural products continued to grow within the period and peaked at around US$7,630 million in 2012, after which it declined to around US$1,402 million in 2015 and US$680 million in 2016 (World Trade Organization, 2017). The export component of this trade stood at N2, 907.21 billion, representing 29.79% of the total trade while import was valued at N6, 850 billion representing 70.21%. The higher level of imports over exports resulted in a trade deficit (in goods) of -N3,943.45 billion. The value of Crude oil export stood at N1,929.83 billion representing 66.38% of the total export recorded in quarter one, 2021, while non-crude oil export accounted for 33.62% of the total export. This development prompted government to initiate several trade agreements, policies/projects and programmes to enhance growth of agricultural output in Nigeria. These policies, which were the theoretical pivots of Nigeria's national development plans (NDPs), show rather disappointing scorecards when measured in relation to the performance of key sectors of the economy including agriculture. In view of the above assertions, the focus of the Nigerian government was redirected toward diversification thereby lifting off restriction on trade export/import of agricultural products (known as trade liberalization of agriculture). Trade liberalization is expected to have an impact on agricultural sector and its export sub-sector through various transmission channels: mainly through exchange rate, capital formation (machinery, equipment, buildings, fertilizers, pesticides, animal feed, drainage and irrigation water and other structures), and prices etc.

Despite the fact that different studies have been conducted in relation to liberalization and agriculture in general, the question of the impact of liberalization of agricultural export has not been sufficiently investigated. Therefore, the study focused on trade liberalization with respect to Nigeria's agricultural sector. The broad objective of this study was to investigate the determinants of agricultural export and trade liberalization in Nigeria. The specific objectives were estimate the short and long run dynamics between agricultural growth and trade liberalization and estimate the determinants of agricultural export in a trade liberalization in Nigeria.

Review Literature

Todaro and Bakare (2011) opined that trade liberalization is the removal of obstacles to free trade (obstacles such as quotas, nominal and effective rates protection and exchange controls. Trade liberalization involves the abolishing of non-tariff barriers to imports, the rationalization and restriction of tariffs, the institution of market determined exchange rate and removal of fiscal disincentives and regulatory deterrents to exports .–Nirodha, Jaime and Jeff (2013) investigated the effect of trade liberalization on agricultural production growth in Sri lanka from 1960 to 2010 and found that, trade liberalization enhances agricultural sector growth and eventually lead to improved agricultural productivity in Sri Lanka. They added that, trade openness, investment, interest rate, Free Trade Agreements are significant factors that are positively related to agricultural sector growth.

Olowe and Ibraheem (2015) investigated the impact of trade liberalization on the growth of the Nigerian economy from 1970-2012 and found that, trade openness, dummy variable for nature of regime of administration in Nigeria at a particular period, exchange rate and dummy variable for structural adjustment program (SAP) periods, trend of trade openness in Nigeria and economic growth has been positive but relatively unstable. John and Bright (2016) explored the relationship between trade liberalization and economic growth in Nigeria from 1980-2013 as Vector Error Correction Model (VECM) was used and found that, openness of the foreign sector and trade liberalization dummy have positive significant impact on both industrial performance and economic growth in Nigeria. Aiyedogbon and Ohwofasa, (2017) examined the impact of trade liberalization on economic growth in Nigeria with vector error correction model and verified the result with Johasen co-integration approach and stationarity tests and found that, at the long run, terms of trade in Nigeria was unfavourable to industrial performance and growth Felix, Kolawole and Musa (2013) conducted a study on trade liberalization and economic growth in Nigeria using co-integration and found that, trade liberalization supports economic growth in Nigeria with an evidence of a long run relationship.

Dutta and Ahmed (2000) used the framework of an endogenous growth model and analyzed the relationship between trade policies and industrial growth in Pakistan. Results showed that, there exists a unique long-run relationship among the aggregate growth function of industrial value added and its major determinants of the real capital stock, the labour force, real exports, and import tariff collection rate. Akanni *et al*. (2008) examined the effect of trade liberalization on agricultural exports in Nigeria, and observed that the policy had tremendous effects on the level and value of exports in agricultural sub-sector.

Theoretical Framework

This study is based on the Heckscher – Ohlin Trade Theory. The Heckscher – Ohlin Theory (H-O model) was developed by Eli Heckscher (1919), and Bertil Ohlin (1933) based on the Ricardian comparative advantage. The model is also called 'factor endowment theory' because it stressed that the pattern of production and trade across national borders depended on the domestic factor endowments. Foreign trade takes place due to the differences in the comparative costs of factors of production that arises, due to the abundant or insufficient resources (labour and capital) within countries. Therefore, countries should produce and export products that they have less expensive factor(s) of production and import goods or inputs that are scarce locally (Blaug, 1992).

METHODOLOGY

This study was conducted in Nigeria. Nigeria is one of the countries located in the sub-Sharan Africa and has a population of over 200 million people with a land area of 923,768km^2 (Abubakar and Aina, 2019) It has abundant natural resources of land, mineral deposits, favorable climate for agriculture and wide expand of savannah and forest areas, rivers and aquatic habitats rich with wide varieties of plant and animal species. Nigeria's agro-climatic conditions favours and encourages the production and export of cash and food crops such as rubber, palm oil, groundnut, The location of Nigeria by the Gulf of Guinea is an added advantage to export promotion Annual data on import and export spanning the period 1999 to 2020 were collected and analysed using appropriate statistical and analytical tools. The data were sourced from Central Bank of Nigeria, statistical book and statement of accounts as well as National Bureau of Statistic (NBS) ~~statistical~~ fact sheets and the World Bank (WB). Agricultural growth variables were used to form the agricultural growth model. The variables; real exchange rate (EXR) which is nominal rate of exchange of the Nigeria naira (N) to the US dollar ($), agricultural output growth (i.e Real Gross Domestic Product (GDP), Agricultural Export ($A_{EXP,}$ Values of Agricultural output measured in Naira), Agricultural Import (A_{IMP}, measured in Naira over time).

Estimation Techniques

A stationarity test of each variable was conducted using augmented Dickey-Fuller (Dickey and Fuller, 1979) Unit Root test (equation 2) in order to avoid spurious regression. Next, a system-wise Johansen co-integration test (Johansen, 1988; Johansen and Juselius, 1990) was used to analyze the presence of the long-run equilibrium relationship among the variables as the variables were integrated at order one 1(1). The presence of co-integration makes an error correction mechanism (ECM) model more applicable. The purpose of the ECM is to indicate the speed of adjustment from the short-run equilibrium to the long-run equilibrium state. Equation 1: stated below represents the model specification for determinants of agricultural exports and trade liberalization Nigeria

$$\boldsymbol{lnAGDP_t} = \boldsymbol{\delta_0} + \boldsymbol{\delta_1 lnEXR_{T-1}} + \boldsymbol{\delta_2 lnAEXP_{T-1}} + \boldsymbol{\delta_3 lnAIMP_{T-1}} + \boldsymbol{\delta_4 lnACF_{T-1}} + \boldsymbol{\delta_5 lnNAP_{T-1}} + \boldsymbol{\delta_6 lnADO_{T-1}} + \boldsymbol{ECM_{T-1}} + \boldsymbol{E_t} \text{ ....(1)}$$

Where: lnR_{GDPt} = Real Gross Domestic Product (measure in Percentage %), lnA_{EXPt} = agricultural export (values of Agricultural output; measure in Naira ₦), lnA_{IMPt} = agricultural import (value of commodity from other countries measure in Naira ₦), $lnREXR_t$ = Rael Exchange rate (Exchange rate which represent a proxy of exchange rate prices at time t), $lnNAP_t$= Nigerian Agricultural productivity (Contribution of Agriculture to GDP.), $lnADO_t$ = Agricultural Degree of openness. (Measured as ratio of Imports + Exports) to the GDP, $lnACF_t$ = Agricultural Capital Formation. (Measure in Naira ₦), ε_t= error term assumed to be normally and independently distributed with zero mean and constant variance, which captured all the other explanatory variables which influence Agricultural growth but were not captured in the model. With regards to the signs of the coefficient trade liberalization model, it is hypothesized that $\boldsymbol{\delta}_0, \boldsymbol{\delta}_1, \boldsymbol{\delta}_2, \boldsymbol{\delta}_3, \boldsymbol{\delta}_4, \boldsymbol{\delta}_5, \boldsymbol{\delta}_6, > 0$.

Auto-regressive Distributed Lag Models (ARDL)

Auto-regressive Distributed Lag Model is a model for time series data in which a regression equation is used to predict current values of a dependent variable based on both the current values of an explanatory variable and the lagged (past period) values of this explanatory variable. The starting point for a distributed lag model is an assumed structure of the form;

$$\mathbf{y_t = \beta + \beta_0 x_t + \beta_1 x_{t-1} + \beta_2 x_{t-2} + \ldots \beta_n x_{t-n} + \varepsilon_t} \text{ .... (2)}$$

where y_t is the value at time period t of the dependent variable y, a is the intercept term to be estimated, and β_i is called the lag weight (also to be estimated) placed on the value i periods previously of the explanatory variables.

The Unit Root Test

The starting point of an empirical analysis of this nature usually begins with the investigation of the properties of the time series. That is, a test of whether the variables in series are stationary at level or at first difference using Augmented Dicker-Fuller. Many economic variables are non-stationary because of shocks, changes and fluctuations over time. For this reason, it is important to conduct preliminary diagnostics tests on the properties of the variables to avoid spurious results and unreliable predictions. Thus, the Augmented Dickey Fuller (ADF) test will be conducted to test for unit root.

$$\mathbf{Y_t = \beta + Y_t + \beta Y_{t-1} + \sum_{i=0}^{n} \beta 1 \Delta Y^i_{t-1}} \text{ .... (3)}$$

$$\mathbf{Y_t = \beta + \beta Y_{t-1} + \sum_{i=0}^{n} \beta 1 \; \Delta Y^i_{t-1}} \text{ .... (4)}$$

Where; Δ = first difference operator, t = the trend variable, Yt = The variable under consideration, ε_t = a white noise error term. Thus, the null hypothesis for the ADF unit root test is: H_0: = 0 (presence of unit root) and alternative hypothesis is H_1: ≠ 0 (absence of unit root)

Co-integration Test

The concept of co-integration is based on the pioneer work of Engle and Granger (1987). The notion of co- integration means movement of variables together. Many financial variables are non-stationary but tend to move together over time, implying that there exist some influences on the series that tie the two series to some long run relationship. In all, a set of variables is said to be co-integrated if a linear combination of them is stationary. Hence, the presence of co-integration between two variables will suggest the existence of a long run relationship and the absence of co-integration will suggest no long run relationship between the two variables.

As such, the reason of testing for co-integration is to verify if such a relationship exists and, if it does, how many co-integrating vectors are present in the relationship.

Results and Discussion

Short and Long Run Dynamics between Agricultural Growth and Trade Liberalization

In a bid to ascertaining the unit root properties of the series that formed the variables of the model, we commenced the analysis by carrying out the Augmented Dickey Fuller (ADF) tests to determine the stationarity properties of the variables. These properties of the variables were ascertained by comparing the calculated values of the respective variable's ADF statistics against their critical values at the 1, 5 and 10 percent levels.

Unit Root and Co-integration Tests

In Table 1, the results of the ADF showed at levels, that is 1(0) both with intercept and no-trend and intercept and trend showed the null hypothesis of no unit root cannot be rejected at the both 10 percent and 5 percent levels of significance except in the case of real gross domestic product (RGDP) and agricultural degree of openness (ADO) that were found to be integrated of the order 1(0). At first difference however, all the series became stationary. That is, they were found to be integrated of order 1(1) (both with intercept and no trend and with trend and intercept). Thus we conclude that the variables are 1(1) process.

Table 1: Augmented dickey fuller (adf) unit root tests for stationarity of the variables in the models

Variable	Levels			1st Difference			Decision
	Constant	Constant and Trend	Without Constant and Trend	Constant	Constant and Trend	Without Constant and Trend	
RGDP	-3.3276**	-3.3531*	-2.4421*	-8.7361***	-4.3399**	-8.9257***	1(0)
ACF	4.5592	-1.0503	8.1319	-2.9456*	-5.5688***	0.0189	1(1)
AEXP	0.3998	-1.6705	1.3943	-4.9864***	-5.2536***	-4.5619***	1(1)
AIMP	0.8431	-5.9990***	2.2020	-6.5221***	-6.9250***	-7.0337***	1(1)
EXR	0.9330	-2.3042	2.8542	-3.7825***	-3.8729**	-3.1807***	1(1)
NAP	-2.2037	-2.6195	1.3121	-6.2218***	-6.4658***	-5.7098***	1(1)
ADO	-3.8990***	-3.3550*	-0.4766	-6.8009**	-6.6535***	-6.9224**	1(0)

Source: Author's computation from E-Views 8.0, Note: ***, **, * denotes 1%, 5% and 10% significant levels respectively.

Table 2: Co-integration Test

			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			-4.682306	0.0009
Test critical values:	1% level		-3.689194	
	5% level		-2.971853	
	10% level		-2.625121	
Variable	Coefficient	Std. Error	t-Statistic	Prob.
RESID01(-1)	-0.764911	0.163362	-4.682306	0.0001
C	-0.380791	0.613193	-0.620996	0.5400

Since the variables were integrated at level, then it was concluded that variables were co-integrated, implying that there exists a short run stability among the variables. The stationarity of variables was established, the bounds test analysis to co-integration were carried out. This gave room for the determination of both long and short run relationships between trade liberalization and agricultural productivities in Nigeria. The ARDL technique was applied as a general VAR model since the unit root properties of the variables have been identified. The next step is to establish the existence of long run relationships among the variables in the model. Table 3 indicates the summary of the results for the ARDL model via the Bounds test procedure for co-integration which shows the connection between agricultural GDP and trade liberalization variables. The hypothesis that the Wald test of the significant variables is equal to zero (0) is invalidated at the 5 percent level of significance from the results. This is because the calculated F-statistics = 5.22 for the trade liberalization model is greater the upper critical bound (UCB). Based on this evidence, we reject the null hypothesis and accept the alternative at both 10 percent and 5 percent levels of significance leading us to conclude that there is a unique long-run association between the variables; thus, the trade liberalization variables can adjudge to be long run determinants of agricultural productivity in Nigeria.

Table 3: The Bounds test

F-Bounds Test		Null Hypothesis: No levels relationship		
Test Statistic	Value	Sign.	I(0)	I(1)
			Asymptotic: n=1000	
F-statistic	5.221388	10%	2.37	3.2
K	8	5%	2.79	3.67
		2.5%	3.15	4.08
		1%	3.65	4.66
Actual Sample Size	25		Finite Sample: n=30	
		10%	2.676	3.586
		5%	3.272	4.306
		1%	4.614	5.966

Source: Author's Computation from E-Views 8.0.
Note: ** indicates co-integration at 5 percent level of significance; k is the number of repressors
I (0) critical value (or lower "bound"), I (1) critical value (or upper "bound")

Short-run Effect of Trade Liberalization on Agricultural Export Performance

To determine the short-run effects of trade liberalization variables on agricultural export performance in Nigeria from 2000 to 2020, the study estimated an over-parametrized model based on one-year lags of the determinants of agricultural export (AEXP) exchange rate (EXR), agricultural export (AEX), agricultural import (AIMP), national agricultural productivity (NAP) and agricultural capital formation (ACF). The result shows that exchange rate (EXR), agricultural export (AEXP), agricultural import (AIMP), and national agricultural productivity (NAP) were all significant at varying level of probability. See Table 4

Table 4: Short-run ARDL Estimates: Trade Liberalization Model

Variable	Coefficient	Std. Error	t-Statistic	Prob.
ln (AGDP (-1))	0.218756	0.082577	2.649097	0.0244
ln(ACF)	-2.63E-07	1.18E-07	-2.230834	0.0498
ln (ACF (-1))	2.34E-07	1.18E-07	1.978559	0.0761
ln(AEXP)	-1.052033	0.199518	-5.272860	0.0004
ln (AEXP (-1))	-0.597814	0.194255	-3.077465	0.0117
ln (AIMP)	2.58E-07	2.55E-08	10.13571	0.0000
ln (AIMP (-1))	-5.36E-08	1.94E-08	-2.758703	0.0202
ln (EXR)	-0.973853	0.100183	-9.720707	0.0000
ln (EXR (-1))	-0.401714	0.110932	-3.621255	0.0047
ln (NAP)	1.81E-07	1.51E-06	0.119834	0.9070
ln (NAP (-1))	-1.17E-05	1.54E-06	-7.623341	0.0000
ECM (-1)	-0.637222	0.063922	-9.968811	0.0000
R-squared	0.927387			
Adjusted R-squared	0.880403			
Durbin-Watson stat	2.329168			

Source: Author's computation from E-Views 7.0., Note: ***, ** and *denote significant at 1, 5 and 10 percent, respectively.

The model shows a significant negative relationship between trade liberalization and agricultural export (AEXP) performance both currently and one year after. Specifically, the study found that an increase in agricultural export by 1 percent, output performance of the sector reduces by 1.1 percent and 5.9 percent in the current and one year later respectively. The value of agricultural import (AIMP) was positively related and significant in determining agricultural export performance in the current year (*P(t)* = 0.0000, 10.14). It implies that 1% increase in agricultural import leads to 2.58% increase in agricultural export performance. However, it still becomes negative and significant after one year lag at 5% level of significant (*P(t)* = -2.7587, 0.02*)*. The value of exchange rate (EXR) was negatively related and significant in determining agricultural export performance in the current year (*P(t)* = 0.0000, 0.9738). This implies that 1% increase in exchange rate will leads to 9.7% decreases in agricultural export performance in the current year. Similarly, it still becomes negative and significant after one year lag at 1% level of significant. This implication is that an increase in exchange rate leads to high cost of foreign investment. Moreover, the value of national agricultural productivity (NAP) was significant at one year lag at 1% level of significant, implying that 1% increase in agricultural productivity will leads to 1.2% in agricultural export performance. Following the Granger Representation Theorem, we specify the ECM model for the co-integrating series in the study. The primary reason for estimating the ECM model is to capture the dynamics in the agricultural GDP performance equation in the short-run and to identify the speed of adjustment as a response to departures from the long-run equilibrium. The ECM coefficient which captures the dynamics in the Agricultural GDP performance to show the speed of adjustment as a response to deviation to long run equilibrium is negative and statistically significantly. In specific terms, the coefficient reveals that 63.7 percent of disequilibrium in the current period would be corrected for in the long run. The adjusted coefficient of determination (R^2) indicates that cumulatively, the variables explained about 92.7 percent of the total variations in agricultural export performance. The Durbin Watson (D.W) indicates a value of 2 implying that there is no auto serial correlation among the variables of the model.

Long-run Effect of Trade Liberalization on Agricultural Export Performance

The long run impact of the trade liberalization variables on agricultural export model based on the ARDL framework is reported in Table 5. The results of the trade liberalization model indicate that all the variables were statistically significant at different level at one-year lag value of agricultural GDP. From the Table, agricultural export (AEX), agricultural degree of openness (ADO), national agricultural productivity (NAP) and agricultural capital formation (ACF) were found to be positively signed and are significant at 1 and 10 percent levels at one-year lag value of agricultural GDP. These were all found to be positive implying that there exist a positive long run relationship between agricultural export, agricultural degree of openness, agricultural capital formation and agricultural export performance. In specific terms, a unit increase in agricultural degree of openness (ADO) and agricultural capital formation (ACF) would lead to a more than proportionate response in agricultural export performance by 2.3 and 3.8 percent respectively while 10 percent increase in national agricultural productivity (NAP) would lead to 7.0 percent. On the other hand, agricultural import (AIMP) and exchange rate (EXR) were negatively signed and significant at 1 and 5 percent respectively and the Coefficient of Multiple Determination indicates that in the long run, trade liberalization variables (model) accounted for 64,19 percent of the changes in agricultural export performance.

Table 5: Long-run ARDL Estimates: Trade Liberalization Model

Dependent Variable: LN_RGDP(-1)				
Sample: 1990 – 2018				
Variable	Coefficient	Std. Error	T-stats	P-value
C	22.67270	18.43781	1.229685	0.2406
linRGDP(-1)	-0.868053	0.229339	-3.785029***	0.0023
d(linAEX(-1))	0.251274	0.047098	5.335106***	0.0000
d(lnAIMP(-1))	-0.333561	0.086604	-3.851541***	0.0005
d(lnEXR(-1))	-1.466718	0.721668	-2.032399*	0.0631
d(lnNAP(-1))	1.709303	0.900046	1.899128*	0.0800
d(lnADO(-1))	0.228404	0.052784	4.327149***	0.0001
d(lnACF(-1))	0.382725	0.112805	3.392800***	0.0018

Source: Author's computation from E-Views 8.0. Note: ∗∗∗, ∗∗, and ∗denote significant at 1, 5, and 10 percent levels, respectively.

CONCLUSION AND RECOMMENDATION

The nature of the economy have made it impossible for the economy to experience growth despite various trade liberalization of the world economy. In order to achieve a meaning development in the agricultural sector in Nigeria, export has to be promoted. This can be done be liberalizing agricultural trade import and export in the country. Promoting agricultural export performance requires efficient management and sound macroeconomics policies in the country and also encouraging indigenous domestic's production for exportation. The study established short and long run relationships between agricultural GDP growth and trade liberalization in Nigeria from 1999-2020. The study recommends that regulating these macro-economic variables will promote agricultural export performance hence, agricultural development, also trade agreements and sound monetary policies should be vigorously enforced to enhance free trade in the ECOWAS sub region. Investment and production in the agricultural sector should be encouraged as output growth may enhanced processing and export of products at the international market.

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Partial Budget Analysis of a Diversified Small Scale Oil Palm Farms in a Changing Climate in Imo and Delta State, Nigeria

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ABSTRACT

Small scale oil palm farmers and /or households, business owners must often make decisions about changes they are either contemplating making or that have to be made. The partial budget is a useful tool for farm managers when these situations arise. There is dearth of information on whether the small change farmers make will decrease, increase or not change net income. A partial budget helps farm owners/managers evaluate the financial effect of incremental changes. Data were analyzed using Partial budget Analysis. Results showed that Net benefit from diversification (N268, 800) is higher than that from oil palm farmers who adopted monoculture technology (N128, 100). Results show that the Rate of return of switching and/or changing from monoculture to diversification is 1.26. Since the alternative change is more economical and greater than one (1), it was recommended that the change to diversification which can reduce financial risk associated with climate change should be accepted and put into practice by farmers in the study area.

INTRODUCTION

Many changes proposed by a manager on a farm affect only part of the business. Therefore, a complete farm budget in not needed to determine the profitability of these specific changes in the operation of the farm. The farmer analyzes only those costs and incomes that change with a proposed business adjustment. He can accomplish this in an organized fashion by using the partial budget, which means that only the relevant costs and incomes are included in the analysis. He can use the partial budget to analyze many practical farm management problems, such as substituting crop and livestock enterprises, changing input levels or types of inputs, changing the size of enterprises in the business and buying new or used machinery, equipment, buildings and facilities (Lessley *et al*,1991).

Farmers are constantly making adjustments in their farms for smooth operations and profitability. Many times, these choices involve actions to enhance the financial return of the farm, while other times these decisions are taken out of necessity to minimize the effects of unfavorable conditions or events such as drought or changes in the market conditions.(Soha El Deep,2014; Ojemade *et al*, 2022)

The partial budgeting is a planning and decision-making framework used to compare the costs and benefits of alternatives faced by a farm business. It focuses only on the changes in income and expenses that would result from implementing a specific alternative. Thus, all aspects of farm profits that are unchanged by the decision can be safely ignored. In a nutshell, partial budgeting allows you to get a better handle on how a decision will affect the profitability of the enterprise, and ultimately the profitability of the farm itself. In using the partial budget only those costs and incomes that change with a proposed business adjustment need to be considered (Hyde, 2023).

Before changing from one production method to another, the farmer considers many factors such as agro-ecological requirements, availability of required production resources (labour, credit, skill, farmland, equipment, etc), additional cost and additional income resulting from the change. (Alimi and Manyong, 2000).

There are possibilities that Agricultural growth requires continuous improvement of crop production technology at the farm level. Agricultural research and extension help develop and transfer appropriate new technologies to farmers. Some new technologies developed on experiment stations are not adopted by farmers because of lack of economic advantage over current production methods.

Farm diversification is an attempt to diversify crops and/or livestock or other efforts by farmers. This is an activity of farmers or households that are often found in agricultural areas in Indonesia, especially crop farming and horticulture. The purpose of this farm diversification is to minimize the risk of loss in certain farm management can even maximize profits (Debertin, 1986; Luat, 2001; Battacharyya 2008 and Kanyua *et al*., 2013).

Luat (2001) states that diversification is a strategy shift of the plant that is not profitable to more profitable crops, from planting system and its variations, increase exports and Competitiveness of the domestic and international markets, safeguarding the environment and create the best combination for Agriculture-Livestock-Forestry and Fisheries. In another sense diversification can also be defined as a shift in farming resources (on-farm resources) to non-farming activities (off-farm resources) or a mixture of both activities are complementary in agriculture (Battacharyya, 2008). Then Kanyua *et al*. (2013) define agricultural diversification as an effort to adjust the pattern of farming that aims to increase farmers' income, reduce income vulnerability and risk.

Loison (2015) exposing classification for diversified livelihoods household by sector (non-agricultural farm), by function (wages-employee and wage own-business), and location (on-off farm). Loison find that diversification not yet benefitted the smallholders in rural, because of asset constraints. As an effort to diversify sources of income, the diversification of activities can be a source of active and passive income.

Many researchers highlight the need for more diversified oil-palm landscapes to mitigate the negative environmental consequences of this recent development (Fitzherbert *et al*., 2008, Foster *et al*., 2011, Koh, 2008, Koh *et al*., 2009). Enterprise diversification is a self-insuring strategy used by farmers to protect against risk (Ashok *et al*, 2004).

Evidence exists that larger farms are more specialized. It aims to minimize losses by investing in different areas that would each react differently to the same event. Most investment professionals agree that, although it does not guarantee against loss, diversification is the most important component of reaching long-range financial goals while minimizing risk. (Ashok and Mishra, 2002).

For decades, rural households are diversifying their sources of income for various socioeconomic and socio-cultural reasons (Atuoye *et al*, 2019). In its current trajectory, diversification of sources of income can lead to food security, income security and rural sustainable livelihood. Nigeria, like many other countries, is exposed to climate change-induced dangers of desertification, erosion, flooding and other ecological problems. Considering the strong nexus between climate change and development, Nigeria is highly at risk in the area of food and nutrition, poverty and hunger reduction, and most importantly, economic development (Ann *et al*, 2013). One of the risk management strategies and/or alternatives that is needed and can enable oil palm farmers build resilience against climate change effects include diversification (Ojemade,2022).

Driven by increased global demand for vegetable oil in the food and biofuel sectors, oil palm plantations based on monoculture technology have expanded into lowland tropical forests. Interest in diversified, mixed oil palm systems is increasing as these might increase efficiency of the use of land and other resources, reduce farmer risk, and decrease greenhouse gas (GHG) emissions per unit product (Khasanah *et al*, 2020).

Oil palm is cultivated as a monoculture or intercropped with other food crops such as cassava, pineapple, yam, plantain, tomato, pepper etc. (Ekhator *et al*., 2013). The only way to increase agricultural production in the small or marginal units of farming is to increase the productivity per unit time and area (Obianefo *et al*., 2020).

Little is known about the small changes oil palm farmers make on their farm businesses and /or enterprises, using climate change adaptation strategies and whether assumptions about the anticipated change by farmers has been initiated, or whether the small change will decrease, increase or not change net income, or if there will be changes in income and expenses that would result from implementing a specific alternative. Consequently, not much is known about which type of analysis aids farm managers, scientist in deciding which type of technology to recommend to farmers .This limits policy making and decision making in the oil palm industry. The objective of the study is to analyze oil palm farmer's business changes on their farms from monoculture to diversification in other to ascertain whether the proposed change from oil palm monoculture to diversification will increase or decrease incomes.

METHODOLOGY

Multistage sampling procedure was adopted to select oil palm farmers for this study. Firstly, was the random selections of two states (Delta and Imo) from the nine states that make up the Niger Delta Area. Secondly, was the random selection of two local government areas (LGA) from each of these 2 States. Thirdly were the random selections of two communities from each of the local government areas, making it up to 8 communities. Finally, ten small scale oil palm farmers were randomly selected from each of the sampled communities, making it up to 80 farmers. The data for this study were obtained with the aid of structured questionnaire survey. Out of the 80 respondents, 52 were utilized for this study. This was due to low response rates, careless responses, obvious misunderstandings, or outright confusions. Also most of the questionnaires were found to be unusable.

For this study, only oil palm farmers who practice oil palm monoculture and have devoted or substituted the same farm land, changed and / or switched to diversification were selected for the study. The unit of measurement in this study was in monetary terms i.e. N/Ha as partial budgets are based on a unit. For this study farmers who engaged or used diversification refer to those who mixed oil palm with other food crops, also engaging in livestock and poultry activities.

Partial budget analysis was used (as in Soha El Deep, 2014, Alimi and Manyong, 2000) i.e. to achieve the objective of the study. Only variable input cost are used in a partial budget (Alimi and Manyong (2000), and not fixed costs. This is because the fixed input does not change from one technology to another. It remains constant regardless of the quantity of output and quantities of other categories of inputs. The price you pay for one hectare for one technology is not going to be different per hectare for another technology.

A partial budget can evaluate changes in resource uses that are not fixed (Dairexnet, 2019).

RESULTS AND DISCUSSION

Table 1. Partial budget of revenue and cost per hectare, for oil palm farmers, who are engaged in and/or using diversification, and those who are not.

Items	Unit price (₦)	Qty (Nos)	Total- Not engaged in diversification	Total –engaged in diversification
Revenue (SALES)	-Bags (palm kernel) -Tin-palm oil. -poultry (Broilers, chicks) -livestock (goat) -food crops eg. maize, cassava, okra.		N256,900	N508,800
VARIABLE COST				
Labour	MAN DAYS N1450-N2,500	14	N20,000	35,000
Seedings	-stands (N145-N250)	140	N21,600	N34,000
Planting	-	-	N15,000	N28,000
Harvesting	-	-	N20,000	N29,000
Fertilizer	-	-	N15,000	N39,000
Herbicides	-	-	N12,500	N17,600
Processing	-	-	N6,000	N15,000
Other cost	-	-	N17,900	N111,400
TVC	--	--		
Total variable cost	-	-	N128,000	N240,000
Net Benefit			N128,100	N268,800

Source: Field Survey, 2022

Change in net benefit between oil palm monoculture and diversification is N140, 700, that is N268, 800-N128, 100.

Change in total variable cost between monoculture and diversification is N240, 000- N128, 800 = N111, 200.

Fixed costs were negligible and most of the farmers were the owners of their land. Costs may not change proportionately when you are changing the size of an existing enterprise. Fixed costs, in particular, may not change much, if any, if the change in size of the enterprise is relatively small.

In addition to change in net income, another criterion, the rate of return (R) is useful for evaluating the economics of adopting a new technology. R measures the increase in net income.ie.

R = NI Δ/ ΔVC (as in Soha El Deep, 2014)

Results show that the Rate of return of switching and/or changing from monoculture to diversification is 1.26 **that is N140, 700 / N111, 200.** This also means diversification is better than oil palm farmers engaged in monoculture in the study area. Results show that diversification is profitable and can increase net income for oil palm farmers in the study area. The rate of return is higher than 1.0, therefore diversification is economically superior. These results are consistent with earlier studies (Soha El Deep, 2014 and Tegegne *et al*, 2021) who observed that the rate of return of changing from one treatment to another was greater than one (1).

CONCLUSION AND RECOMMENDATIONS

The study has shown that a different option can allow farmers to overcome an environmental effect of climate change which is diversification. Diversification can increase smallholder incomes. Based on partial budget results, oil palm farmers in Imo and Delta states should consider change to diversification. Results also revealed that diversification is economically superior and socially accepted by farmers in the study area than monoculture. Diversification can spread production and economic risk over a broader range of crops, reducing financial risk associated with climate change. Alternative choices within an individual enterprise can have a positive effect on farm profitability. Making the best decision may make the difference between profit and loss for that enterprise. The study therefore recommends that oil palm farmers should make the change to diversification. Training is required to ensure that oil palm sole cropping and /or monoculture is planned and implemented as an organized system, which can lead to increased benefits.

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Climate Change Adaptation Practices of Rural Farmers in Benue and Kano States of Nigeria

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ABSTRACT

Global climate change impacts have recently become the most devastating human problem become climate change causes remain substantially unabated. Rural farming communities in Nigeria have suffered varying degrees of climate vulnerabilities resulting in wanton destruction of live and property. To offset ravaging impacts of climate change, rural communities in Benue and Kano State developed coping strategies in the form of deforestation for arable agriculture, firewood marking, logging, charcoal production, furniture/wood working and wanton exploitation of non- forest resources. These coping strategies rather destroyed the landscapes and increased vulnerabilities in the communities. Climate change adaptation pilot project component of the "Building Nigeria's Response to climate change" (BNRCC) Project was experiment in Daudu and Falgore communities of Benue and Kano State respectively to alleviate the increasing vulnerabilities of the rural communities. The locals adopted various sustainable climate change adaptation initiatives to build resilience. Reduce poverty and improve living conditions of the vulnerable population especially women, youths and children. The success of these adaptation activities has generated wide scale replication among several farming communities around primary beneficiary sites in Benue and Kano States of Nigeria. This paper examined the successful climate change adaptation initiatives of the BNRCC pilot project being replicated in other farming communities in Benue and Kano States and the challenges faced by the farmers in implementing those adaptation initiatives.

INTRODUCTION

Daudu and Falgore communities in Benue and Kano State respectively were selected as sites for implementing "Building Nigeria's Response to climate change (BNRCC)" pilot project in 2009. The BNRCC pilot project was attracted to the communities by a non-government organization known as Green watch Initiative. The organization had previous knowledge of the adaptation needs of these mainly agrarian communities. Vulnerability assessment was done to identify most affected and less influential stakeholder, climate change event, impact and community responses, vulnerable group/features, community structure, resources and most vulnerable area in the community (BNRCC,2010). Community- driven and gender sensitive approaches were used to facilitate the adoption of sustainable climate friendly adaptation practices which were established in Daudu and Falgore communities in Benue and Kano State respectively. The BNRCC pilot project beneficiaries experienced high crop yield, reduced poverty and increased living condition the success stories motivated neighboring communities to replicate the successful climate change adaptation practices to build resilience and reduce vulnerability.

Prior to the introduction of the adaption project, rural communities in Benue and Kano State were experiencing severe impacts of climate change culminating in declining agricultural productivity, increasing morbidity and mortality, drought, flooding and increasing energy demand. These and the chain of causal reactions were known to have aggravated poverty and negatively affected livelihood of the people especially woman, youth and children (BNRCC, 2010). Coping strategies used by the locals included wanton deforestation for charcoal production and fuel wood, tradition arable farming, logging and exploitation for non-timber forest products (FAO,2007;NEST, 2004). These coping strategies provided short term relief to the farmer but ended up devastating more of the environment and inflicting severe damage on the people (IUCN,2006). Climate change impact had substantially destroyed lives and properties due to extreme famine, flooding, drought, erosion, biodiversity loss and conflict arising from competition for scarce resource (UNEP,2005) word Development Repost (2010) had repost that in the absence of clear near term climate change mitigation programmers, climate change events would continue to deepen vulnerabilities, erode hard-won gains and seriously undermine prospects for development. The repost of inter-government panel on climate change (IPCC,2007) established that ever if all climate change causes were halted immediately, the carbon footprints in circulation would inflict climate change calamities on humanity for the next 50 years, hence for enhanced resilience's building and climate change adaptation practices in the communities.

Climate change adaptation initative being implemented in Daudu and Falgore communities

According to BNRCC (2010) the successful climate change adaptation practices being replicated by rural farmers in Benue and Kano state includes the following:

i. Climate change sensitization: Rural farmers in Benue and Kano state are highly sensitive to climate change events and they reacted positively to climate predictions/daily weather forecast by organizing their tasks to fall within favourable periods. Annual rainfall/climate predictions by Nigerian meteorological agency (NIMET) assist farmers in planning the time of cultivation, planting, fertilizers applications, harvest, etc.

ii. Use of improved crop varies: farmers have substituted low-yield traditional crops with early maturing, drought/pest resistant and high yielding crop varieties, in Benue state, crop mostly produced include yam, rice, groundnut, maize, soybean, cassava, potato, guinea corn, beniseed, pepper, tomato, and vegetable. In Kano state maize, rice, groundnut, sugar, onions, vegetable and pepper are produced in large quantities using improved varieties.

iii. Cash crop production: orchard of improved varieties of cash crop like orange mango, oil palm an guava are established by farmers to in Benue state as a means of accruing perennial income with less effort. In Kano state orchards of *Acacia spp* and orange are being developed by some farmers to augment family income.

iv. Dry season farming: farmers along perennial streams and rivers in Benue and Kano state practice dry season farming using engine water pumps to irrigate their farms. Crops mostly grown include early maturing rice, onions and pepper. In some communities of Kano state, dry season irrigation is achieved through the use of irrigation canals and engine powered wash wells.

v. Low cost wood efficient stoves: various kind of low cost wood-efficient stoves are used by households for domestic cooking in Benue and Kano state. The stoves use less wood/charcoal and cook faster than conventional wood-burning stove that use more wood. The use of these stoves has reduced wood exploitations and consequently lowered the rate of deforestation in the communities.

vi. Livelihood diversification: falling fish catches and crop failure had led to an upsurge of various livelihood activities such as fish and poultry farming, animal husbandry and bee-keeping in order to diversify family income.

Challenges to effective practice of climate adaptation initiatives by farmers in Benue and Kano states

Despite widespread replication of climate change adaption initiatives by rural farmers in Benue and Kano states, there were still challenges to the effective practice of these adaptation initiatives, and these includes the following:

i. Conflict due to competition for resources: there are increasing cases of conflict among farmers themselves and between farmers and pastoralists over land and water resources, conflicts arising from competitions for arable land and scares water points have led to the wanton loss of lives ad properties with several internally displaced people talking refuge in camps especially in Benue state. Farmers in those communities are unable to farm and therefore face severe food shortage and malnutrition.

ii. Post-harvest losses: farmers experience high yield from cultivation of improved crop varies, but loss over 40% of the produce due to spoilage as a result of lack of processing and storage facilities, hence, gain accruable from climate change adaptation practice are lost to post harvest spoilage, farmers of perishable crops are most times unable reap the fruits of their labor.

iii. Use of pesticides and herbicides: there is widespread application of pesticides and herbicides to control pest and weed on the farmlands in Benue and Kano state. The chemicals with their high level of toxicity are absorbed by crops and finally transferred to man through food chain. Parts of the chemicals settle in the soil and also in the ground water which have concomitant effect on soil micro fauna. Increase cases of renal failures and liver disease are attributed to excessive exposure to bio-degradable chemicals.

iv. Prevalence of coping strategies: illegal logging, commercial fuelwood exploitation and charcoal productions were still on the rise in Benue and Kano state. These have resulted in massive deforestation and gradual incursion of aridity. Some farming families still indulge in these activities despite early warning measures.

v. Frequency if climate change impacts: farmers' resilience is often overwhelmed by frequent incidence of climate events like flooding, heat waves. Prolonged drought and epidemics which destroys crops, livestock, lives and property, as well as the environment.

vi. Financial barriers are one of the key barriers that restrict farmers in Benue State to climate change adaptation strategies (Peterson, 2013). Financial barriers are largely related to budget deficits experienced in many States across nation (Adejuwon 2004). Every form of adaptation entails some direct or indirect financial costs. For instance, the uses of improved varieties of crops has been reported as one of the key adaptation strategies for farmers in Benue State (BNRCC, 2010).

vii. Adequate information on climate change characteristics is a very powerful tool that can be used to enhance the adaptation strategies by farmers in Benue State this is particularly important for Nigeria (IPCC,2007) and Benue State, where there are few considering that most farmers in Benue State depend on rain-fed agricultural systems. Hence, lack of appropriate climate information could be critical for food security in the area Evan though NIMET has been providing the state with climate information, it usually come in the form of seasonal forecasts that may not be useful in long-term planning of agricultural activities (Ziervogel *et al*., 2010). This has often lead to food insecurity in the state. The information barriers to climate change adaptation action by the farmers in the state, may be similar to finding by Adger *et al* (2009), who suggested that information and awareness on climate change adaptation strategies could potentially serve as barrier to successful implementation of adaptation practices. Flood. preparedness involves the development of emergency plan and early warning systems that have the capacity to provide real-time climate information to aid decision making on flood. Providing early warning system and climate risk information for flood. Mitigation has been acknowledged by major international conferences. One of the key policy priorities at the world summit on Sustainable Development was the provision of early warning system that are affordable and locally available to the people so as to enhance timely responses to incidences of flood. Successful implementation of climate adaptation strategies requires that farmers do not only have sufficient knowledge about the available options, but have adequate capability to assess the available option so as to make informed decision on the best adaptation strategies (Lee, 2007).

viii. The lack of appropriate information on climate change characteristics could be related to the lack of adequate and state-of – the art equipment at meteorological department across the state. Many of the weather stations are ill-equipped to produce real-time scale climate information for adaptation .this prevents the time predication and forecast of the rainfall pattern to enable farmers to make informed decision farmers in Benue State use their indigenous and agro-ecological knowledge, based on the past experience, to form complex mental models of the climate with which they forecast the weather.

The Way Forward

Provision of credit facilities for climate adaptation strategies in the state. Government should liaise with bank to extend credit facilities to farmers. Because most farmers in the state cannot provide the necessary collateral that bank demand for the provision of credit. It is significant to stress that it is most desirable to give financial assistance to farmers at the beginning of the farming season e.g. provision of flood resistance crops, provision of fertilizers, hire tractors to prepare their farm land and purchase involved in granting credit facilities and loan to farmers should be initiated well in advance of the farming season.

Development of early warning system and effective communication channels for climate adaptation: Nigerian government should invest heavily in early warning systems on drought and floods to aid farmers in planning their farming operations. Effective communication of information on climate change strategies adaptation is essential for adaptation by farmers as communication increases understanding and awareness (Moser, 2011). In this regard appropriate communication mechanisms including the use of local radio stations broadcasting in local dialect could be used to ensure that such climate information and warnings reach the intended farmers.

Improving human capital development to facilitate climate adaptation: Nigeria has low expertise in climate research (NEST,2004). Hence, there should be concerted efforts to improve the overall human capital development in order to improve quality research into climate-related hazards. The role of extension services in agricultural adaptation to climate change has been documented in Nigeria (Mustapha *et al*., 2012). Efforts should be made by policy markers both at national, satate and local government levels to improve farming practices by strengthening the capacity of extension officers through increased staff number and training of staff with different specialists linked to different crops, especially staple crops such as maize, rice vegetables and cassava that hold great prospect for food security in the state in particular and to the country as a whole.

Appropriate institutional and Policy Environments: Appropriate institutional and Policy environments should be created for climate adaptations. Supportive institutional framework at the local, state, national and international levels is critical in enabling successful climate change adaptation strategies to the farmers in the rural communities of Benue State. In addition, there is a need for proper coordination amongst the various institutions involved in climate adaptation programmes. There should be close collaboration between the meteorological services and extension services for forecasts to be made available to farmers for climate change adaptation actions in the state.

CONCLUSION AND RECOMMENDATION

Climate change adaptation initiatives adopted by farmers in Benue and Kano States have assisted in building resilience to climate change impact and development alternative income source for the families. However, the quantum of challenges faced by farmers while implementing these adaption approaches has the capacity to undermine all the gains recorded in the process if not immediately addressed. It is therefore recommended that concerted efforts should be made by relevant governmental and non-governmental agencies in addressing these observed challenges and mitigating climate change causes. Halting climate change causes will substantially reduce poverty and improved quantity of life of the people.

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SUB-THEME 7

ISSUES OF BIODIVERSITY AND BIOTECHNOLOGY IN THE ERA OF CLIMATE CHANGE

Ethnobotany and Chemistry of Selected Plants in the Rutaceae Family

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KEYWORDS

Rutaceae;
Ethnomedicinal Materials;
Phytochemicals;
Alkaloids;
Phenols

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ABSTRACT

Plants in the Rutaceae family are widely distributed across the globe. They are important sources of ethnomedicinal materials and also rich in phytochemicals. This work focuses on some of the ethnobotanical uses and phytochemical composition of four (4) plant species belonging to the Rutaceae family, viz: Sweet Orange (Citrus sinensis L. Osbeck), Persian Lime (Citrus latifolia Yu. Tanaka), Tangerine (Citrus tangerina Tanaka) and Lemon (Citrus limon (L.) Osbeck). It was revealed that different parts of the plants have been found useful in curing and managing ailments such as infertility, cancer, diabetes mellitus, and cholera among others. Important chemicals including but not limited to alkaloids, carotenoids, flavonoids, tannins, phenols, and terpenoids have also been identified in the plants. Similar review should be carried out on other taxonomic families so that there would be comprehensive documentation of the ethnobotanical relevance and phytochemical constituents of many plant families.

INTRODUCTION

The history of medicinal plants goes back thousands of years when ancient cultures used plants to treat a wide range of illnesses, some of which are still used today (Yuan *et al*., 2016; Salmerón-Manzano *et al*., 2020). Many traditional remedies have been passed down through generations and continue to be used in some parts of the world (Che *et al*., 2017). In recent times, modern science has begun to explore the potential of medicinal plants and their active compounds.

The chemistry of medicinal plants has been studied extensively by many researchers and has revealed a variety of compounds that can be used to treat a range of medical conditions (Altemimi *et al*., 2017). These compounds can be found in a variety of plants, from herbs and shrubs to trees and vines. The chemical compounds vary from plant to plant, but they all have the potential to be used as treatments. In addition to the active compounds, some plants also contain other beneficial compounds such as antioxidants, anti-inflammatories, and other bioactive molecules that can be used to treat a range of medical conditions (Suffredini *et al*., 2004). The combination of ethnobotany and chemistry brings together the traditional knowledge of medicinal plants and the scientific knowledge of their active compounds (Heredia *et al*., 2022). This combination can be used to develop new treatments and to improve existing treatments. Ethnobotany can provide insight into the traditional uses of medicinal plants (Wanjohi *et al*., 2020) and the chemistry of medicinal plants can reveal the active compounds that can be used to treat various medical conditions (Egbuna *et al*., 2020).

The chemistry of plants is enshrined in the metabolites or organic compounds synthesized by the plants. These metabolites, also called phytochemicals are responsible for the medicinal effects these plants have on their users. The components of the chemicals found in certain plants are a major factor in their individual species' special characteristics and medicinal qualities, which is why they are used widely in medical practice (Lovkova *et al*., 2001). It is common knowledge that all plants produce chemicals that give them certain advantages such as defense, growth, and pollinator attraction, to mention a few (*Hayat and Ahmad, 2007). Some of these chemicals have potential use in drug production. For instance,* quinine *is a compound obtained from Cinchona succirubra and has been found effective in treating malaria (Willcox, 2004).*

Due to the diverse forms and structures of phytochemicals, their exact classifications are not universal (Deepak *et al*., 2016). However, a broad classification put them into primary and secondary metabolites, depending on the roles they play in plant metabolism (Ramawat *et al*., 2009). Primary metabolites include but are not limited to carbohydrates, lipids, proteins, amino acids, and nucleic acids, while secondary metabolites are the other plant chemicals such as alkaloids, terpenoids, and phenolics which do not serve principal functions in the plant (Hahn, 1998).

Ethnobotany

The word ethnobotany is derived from two different words, *ethno*- (ethnic) which means culture, race or people and *botany* which comes from the Greek word *botanē* meaning herbs, pasture or grass (Chavda *et al*., 2022). Hence, ethnobotany can be described as the utilization of herbs in different cultures. The term "ethnobotany" was first used in 1895 by the botanist, John, W. Harsherberg who defined it as "the use of plants by primitive and aboriginal peoples" (Serge and Claire, 2018). Several other definitions have been given to the term by different authors. According to Vokes (2017), "ethnobotany is the study of the dynamic relationship between plants and people". The United State Department of Agriculture (USDA, 2008) defined ethnobotany as "the study of how people of a particular culture and region make use of indigenous (native) plants". Ethnobotany is a distinct field of research yet with a strong multidisciplinary outlook (Schultes, 2016). Several researchers over the years have attempted to highlight the multidisciplinary nature of ethnobotany. Suthari *et al*. (2021) underscored the prominent utility patterns of ethnobotany in various disciplines of science (Figure 1).

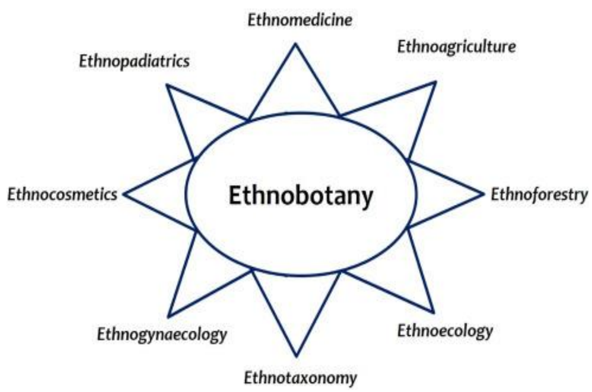


Figure 1: Major utility patterns of ethnobotany in different science disciplines (Suthari *et al*., 2021).
Chemistry

Chemistry is a broad field that a single definition may not capture its scope. Brown *et al*. (2018) described chemistry as the scientific study of the properties and behaviour of matter. The Merriam-Webster dictionary explained chemistry as "a science that deals with the composition, structure, and properties of substances and with the transformations that they undergo." Chemistry addresses concepts such as matter, atoms, molecules, elements, compounds, ions, and chemical bonds to mention a few. It is no exaggeration that no part of our day-to-day life is devoid of one chemical activity or the other. We find chemistry in our food, drink, clothing, gadgets, buildings, and a host of other things.

In the context of ethnobotany, chemistry studies the composition of plants, especially medicinal plants. Hence, chemistry becomes relevant in the study of ethnobotany as it deals with chemicals (phytochemicals) produced by plants. This is referred to as phytochemistry. "Phytochemistry considers the structural compositions of plant metabolites, the biosynthetic pathways, functions, mechanisms of actions in the living systems as well as its medicinal, industrial, and commercial applications" (Egbuna *et al*., 2020). Phytochemicals have great antioxidant properties and are of great interest due to their valuable effects on human health, and they give enormous health benefits to consumers (Thakur *et al*., 2020).

There is no universally agreed classification of phytochemicals because there are tens of thousands of them that have been discovered. However, Egbuna *et al*. (2020) classified them into phenolics, terpenes, terpenoids, N-, and S-containing compounds.

Table 1: Classification of common phytochemicals

Major class	**Subclasses**	**Representatives**
Phenolics	Polyphenols	Flavonoids, isoflavonoids, chalconoids, lignans, stilbenoids (e.g., resveratrol), curcuminoids, and tannins (e.g., protocatechuic and chlorogenic acids).
	Aromatic acid	Phenolic acids (e.g., gallic acid, tannic acid, vanillin, ellagic acid), hydroxycinnamic acids (e.g., coumarin)
Terpenes	Monoterpenes	Geraniol, limonene, pyrethroids, myrcene
	Sesquiterpenes	Costunolides
	Diterpenes	Abietic acid, cafestol, gibberellins
	Triterpenes	Azadirachtin, phytoecdysones
	Polyterpenes	Tetraterpenes, for example, carotenoids, rubber
Terpenoids	Carotenoids (tetraterpenoids)	β-carotene, lycopene, phytoene
	Xanthophylls	Lutein, zeaxanthin
	Triterpenoid	Saponins, ursolic acid
	Steroids	Tocopherols (vitamin E), phytosterols (β-sitosterol, campesterol)
N (organonitrides)	Alkaloids	Nicotine, morphine, caffeine, theobromine, theophylline
	Cyanogenic glucosides	
	Nonprotein amino acids	Canavanine, azetidine-2-carboxylic acid
S (organosulfides)	Allicin, alliin, piperine	
	Glutathione, phytoalexins	
Others	Phytic acid, oxalic acid, tartaric acid, malic acid, quinic acid	

Source: Egbuna *et al.* (2020)

Rutaceae

Rutaceae is a family of flowering plants that includes shrubs and trees in the order Sapindales (Appelhans *et al*., 2021). The family is commonly referred to as the citrus family. The Rutacea family is widespread and highly diverse, with about 2100 species in 154 genera (Kubitzki *et al*., 2011). The family is found in tropical and subtropical regions, with a few species occurring in temperate climates (Appelhans *et al*., 2021). The leaves of plants in the Rutaceae family are typically opposite or alternate and are often pinnately or palmately compound (Brizicky, 1962). The flowers are small and typically have four or five petals and sepals (Brizicky, 1962). The family is best known for its citrus fruits, which include oranges, lemons, limes, and grapefruits. Other important members of the family include the rutas, or rue plants, which have a long history of medicinal use, and the euodias, which produce an essential oil used in perfumes. The taxonomic hierarchy of the Rutaceae family is shown in Table 2. The selected plants in the Rutacea family for this study are Sweet Orange (*Citrus sinensis* L. Osbeck), Persian Lime (*Citrus latifolia* Yu. Tanaka), Tangerine (*Citrus tangerina* Tanaka) and Lemon (*Citrus limon* (L.) Osbeck) (Plate 1-4).

Table 2: Taxonomic hierarchy of Rutaceae family

Kingdom	**Plantae – plantes, Planta, Vegetal, plants**
Subkingdom	Vindiplantae – green plants
Infrakingdom	Streptophyta – land plants
Superdivision	Embryophyta
Division	Tracheophyta – vascular plants, tracheophytes
Subdivision	Spermatophytina – spermatophytes, seed plants, phanerogames
Class	Magnoliopsida
Superorder	Rosanae
Order	Sapindales
Family	Rutaceae – rues, rutacees

Source: Integrated Taxonomic Information System

Plate 1: Sweet Orange (Citrus sinensis L. Osbeck) (Source: https://pfaf.org/)

Plate 2: Persian Lime (Citrus latifolia Yu. Tanaka) (Source: Grayum, 2012)

Plate 3: Tangerine (Citrus tangerina Tanaka) (Source: https://www.needpix.com/)

Plate 4: Lemon (*Citrus limon* (L.) Osbeck) (Source: Royal Botanical Gardens Kew)

Ethnobotany and Chemistry of Selected Plants in the Rutaceae Family

The ethnobotanical uses of the selected plants in the citrus family have been documented in the literature. Some of the uses are summarized in Table 3.

Table 3: Ethnobotany and phytochemical constituents of selected plants in the Rutaceae family

Plant	Disease treated	Plant part used	Method of preparation and use	Phytochemical constituents	Reference
Citrus sinensis	Infertility in human	Juice	Stem of *Xylopia aethiopica*, fruit of *Citrullus colocynthis* and leaves of *Lagenaria breviflora* is dried and grinded and mixed with the juice of sweet orange. One teaspoonful to be taken orally every morning for 9 days.	Alkaloids, amino acids, carbohydrates, carotenoids, flavonoids, steroids, tannins, phenols, terpenoids	Okwu, 2008; Chede, 2012; Mathew *et al*., 2012; Soladoye *et al*., 2014; Oikeh *et al*., 2015; Chaudhari *et al*., 2016; Lawal and Olagoke; 2016; Roghini and Vijayalakshmi, 2018; Khandla *et al*., 2020.
	Citrus sinensis has also been used to treat arthritis, asthma, Alzheimer's disease, cholera, macular degeneration, gallstones, multiple sclerosis, gingivitis, Parkinson's disease, diabetes mellitus, cataracts, ulcerative colitis, and Crohn's disease. The peel is also used as mosquito repellents in many local communities.				

Citrus latifolia	Cancer in human	Juice	Root of *Calliandra haematocephalaare*, bark of *Bridellia ferruginea*, bark *Mangifera indica*, bark of *Tricalysia macrophylla*, bark of *Antiaris africana*, bark of *Trichilia monadalpha*, leaves of *Allium ascalonicum* and bark of *Nauclea latifolia* rinsed and boiled in water for 40 minutes. Lime juice is added when cooled and it is taken three times daily for 2 months	Alkaloids, amino acids, carbohydrate, carotenoids, flavonoids, steroids, tannins, phenols, saponins, terpenoids	Aiyeloja and Bello, 2006; Okwu, 2008; Soladoye *et al*., 2010; Chede, 2012; Mathew *et al*., 2012; Oikeh *et al*., 2015; Chaudhari *et al*., 2016; Roghini and Vijayalakshmi, 2018; Khandla *et al*., 2020.
		Root	Seed of *Xylopia aethiopica*, seed of *Aframomum melegueta*, root of *Plumbago zeylanica* and root of lime should be ground together smoothly and mixed with black soap and gun powder. Use the preparation to wash all the parts of the body, once a week		
Citrus tangerine	Citrus tangerine has been used as or in the management of diseases relating to the abdomen, aches, antidote, dysmenorrhea, anodyne, dyspepsia, panacea, antiseptic, bactericide, refrigerant, pectoral, bubo, diarrhea, breast cancer, stomach cancer, carminative, pimple, chest congestion, deobstruent, dyspnea, emmenagogue, freckle, fungicide, gas, prolapse, nausea, marasmus, rectocele, rib, sedative, sore, spasm, splenitis, stomach, stomachic, thirst, urogenital, uterus, vermifuge, wine-Nose.			Alkaloids, amino acids, carbohydrates, carotenoids, flavonoids, steroids, tannins, phenols, saponins, terpenoids	Aiyeloja and Bello, 2006; Okwu, 2008; Bibalani and Sayadmahaleh, 2011; Suryawanshi, 2011; Chede, 2012; Mathew *et al*., 2012; Oikeh *et al*., 2015; Chaudhari *et al*., 2016; Roghini and Vijayalakshmi, 2018; Khandla *et al*., 2020.
Citrus limon	Worm	Juice	Raw juice should be taken every day before the meal.	Alkaloids, amino acids, carbohydrates, carotenoids, flavonoids, steroids, tannins, phenols, saponins, terpenoids	Aiyeloja and Bello, 2006; Okwu, 2008; Soladoye *et al*., 2010; Chede, 2012; Mathew *et al*., 2012; Soladoye *et al*., 2014; Oikeh *et al*., 2015; Roghini and Vijayalakshmi, 2018; Khandla *et al*., 2020.
	Cancer in human	Juice	Leaves of *Nymphaea lotus*, leaves of *Pistia stratiotes*, crushed stem of *Saccharum offinarum*, bark of *Morinda lucida* and seed of *Xylopia aethiopica* are rinsed and boiled in 1L of lemon juice and palm oil for 3 hours. Two teaspoonful morning and night.		

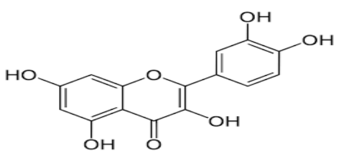
The phytochemical constituents of the plants and their abundance have also been documented. Table 4 presents the phytochemical composition of the plants.

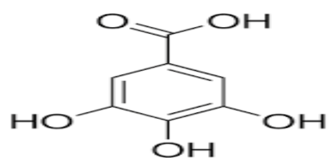
Table 4: Phytochemical constituents of selected plants in the Rutaceae family

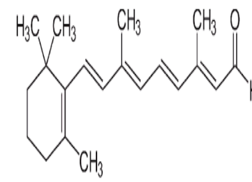
	Citrus sinensis		***Citrus latifolia***		***Citrus tangerina***		***Citrus limon***	
Phytochemicals	EE	AE	EE	AE	EE	AE	EE	AE
Alkaloids	+	+	+	+	++	*	++	++
Phenols	+	+	+	+	+	*	+	+
Flavonoids	+	+	+	+	+	*	+	+
Steroids	+	+	+	+	++	*	+	+
Terpenoids	+	-	+	+	++	*	+	+
Saponins	-	-	+	+	++	*	+	+
Reducing sugar	+	+	+	+	+	*	+	+
Tannins	+	+	+	+	+	*	+	+
Carbohydrate	+	+	+	+	++	*	+	+

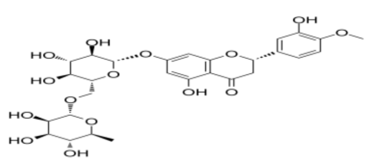
Source: Chede (2012); Mathew *et al*. (2012); Oikeh *et al*. (2015); Roghini and Vijayalakshmi (2018)
EE = ether extract; AE = aqueous extract; + = slightly present; ++ = highly present; - = absent; * = no reliable source to depend on

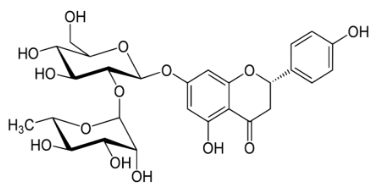
Literature (Okwu, 2008; Roghini and Vijayalakshmi, 2018; Khandla *et al*., 2020) has also shown some of the representatives of the major phytochemicals present in the selected plants. They are Quercetin, Gallic acid, Hesperidin, Naringin, Tangeritin, Rutin, Limonene, β-Carotene, Lycopene, Lutein, Zeaxanthin, and Retinal (Figure 2).

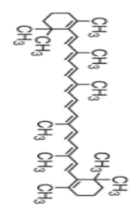

Quercetin

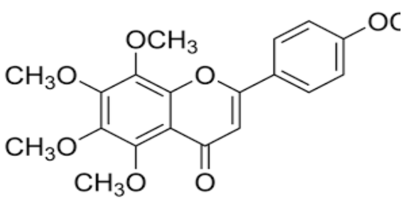

Gallic acid

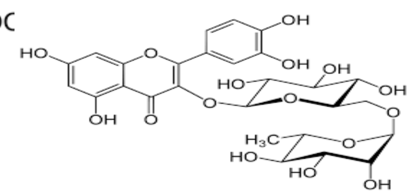

Retinal

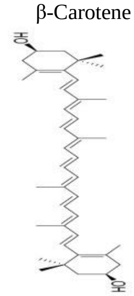

Hesperidin


Naringin


β-Carotene


Tangeritin


Rutin


Zeaxanthin

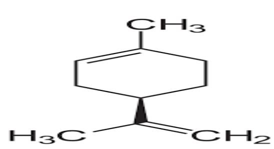

Limonene

Figure 2: Chemical structure of the representatives of the phytochemicals present in the selected plants

CONCLUSION

This work revealed that the Rutaceae family is an important taxonomic family whose members are ethnobotanically relevant and rich in phytochemicals. More of this documentation should be extended to other taxonomic families. In this modern world, it is not sufficient to know and understand what the local people use each plant species for, rather scientific backings are required to validate the claims, and this will be known by phytochemically screening the plant species.

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Effects of Herbicide Application on Soil Bacterial Load under Ginger Production in Kaduna, Nigeria

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K E Y W O R D S

Bacteria,
Effect,
Herbicides,
Soil

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A B S T R A C T

Herbicides are commonly used to control weeds in crop productions, in addition to their impact on weeds, these herbicides are also affecting soil microorganisms which are responsible for numerous biological processes essential for crop production. This study was undertaken to determine the some selected physicochemical property of the soil, assess the effects of herbicide application on bacterial load and to identify the bacteria that are presents in the soil samples for the sampling sites. A soil sample that had history of herbicides application was collected from National Root Crops Research Institute Ginger Station, Kajuru, Kaduna State. The physicochemical analysis of the soil property was carried out based on the standard procedures and the colony counts were obtained using serial dilution technique. Bacteria were isolated and identified based on colonial and biochemical characteristics. Results obtained showed that each sampling point had an average bacterial counts of; Point A (1.4×10^6 cfu/g), Point B (1.5×10^6 cfu/g), Point C (1.4×10^6 cfu/g) and Point D which is the control (2.7×10^6 cfu/g). The bacterial isolates obtained in the study included Proteus sp., Staphylococcus sp., Micrococcus sp., Staphylococcus sp., Bacillus sp. and Enterobacter sp. Conclusively, this study shows that use of herbicides applications at field recommended rate may not have an adverse effects on the bacterial load.

INTRODUCTION

Fertile soil is inhabited by the root systems of higher plants, rodents, insects and worms and tremendous numbers of microorganisms. Usually, the density of organisms is less in cultivated soil than uncultivated/virgin land and population decreases with soil acidity (Stanley, *et al.*, 2013). In modern agricultural production, herbicide application is a regular practice. The problems caused by the increased application of herbicides and resulted in decreases of number of soil microorganisms Stanley, *et al.* (2013). Herbicides are chemical substances or preparations designed to kill plants, especially weeds, or to inhibit their growth. Herbicides for example Atrazine, Paraquat, Glyphosate etc become incorporated in soil directly, during plant treatment and indirectly, via water or residues of plant and animal origin (Stanley, *et al.*, 2013).

The increased use of herbicides in agricultural soils causes the contamination of the soil with toxic chemicals. When herbicides are applied, the possibilities exist that these chemicals may exert certain effects on non-target organisms, including soil bacteria (Parkinson, 1990). The microbial biomass plays an important role in the soil ecosystem where they fulfill a crucial role in nutrient cycling and decomposition (De-Lorenzo *et al*., 2001).

Atrazine is an example of triazine herbicides with the trade name, Multrazine. The triazines were shown to inhibit photosystem II (Trebst, 2008) while paraquat is an example of quaternary ammonium herbicides with the trade name, Gramoxone. Paraquat is known to act on the Phosystem I within the photosynthetic membrane of plants. On microorganisms, they have inhibitory effects, repressing effects, reduces enzyme activity and mycelia growth. Having known the actions of these herbicides on plants the aim and objectives of the present study were to determine the physicochemical property of the soil, assess the effects of herbicide application on bacterial load as an indicators of soil fertility and to identify the bacteria that are presents in the soil for the sampling sites.

MATERIALS AND METHODS

Sampling Site

A soil samples were collected from four different sampling points (ABCD) from a ginger research farm of the National Root Crops Research Institute, Maro, Kajuru Local Government, Kaduna State. The farm is located at Iburu along Kachia road 20 Km away from Kajuru. Kajuru Local Government Area is located on longitude 9º 59'N and 10º 55'N and latitude 7º 34'E and 8º 13'E with an area of 2464km^2 (Toro, 2001). The ecology of the study area is underlain by gneisses, migmatites and metasediments of the Precambrian age which have been intruded by a series of granitic rocks of late Precambrian to lower Palaeozoic age. The entire land structure consists of an undulating Plateau with major rivers in the State including River Kaduna in addition to several streams. The whole state is covered by the red-brown to red-yellow ferruginous tropical soils which are heavily weathered and markedly laterized. They are mostly formed on granite and gneiss parent materials, and on aeolian and many sedimentary deposits. The study area is covered by the tropical grassland vegetation with the density of trees and other plants decreasing as one move northwards (Iliya *et al*., 2015). The climate of the study area is the tropical dry-and-wet type. The wet season lasts from April through mid-October with a peak in August, while the dry season extends from mid- October of one calendar-year to April of the next year. The annual average rainfall in the state is about 1323mm (Iliya *et al*., 2015).

Sample Collection:

Soil sampling was started from a distance of 3m away from the farm land border into the farmland where soil samples were collected every distance of 50m inside clean polythene bags from four different sampling points (ABCD). A modified sterile soil core sampler was used at a depth of 20cm and to ensure a fair representation of soil sample, the sample was collected in triplicate to form a composite of about 1kg of the soil. The field was solely ginger farm and the management was done both chemical (Herbicides) and manual (Hand picking). The Herbicides used were Paraquat, Glyphosate and Atrazine. Herbicides were applied 4 to 5 weeks after planting at the rate of 4L/Hectre each before shoots to emerge. The soil samples were divided into two for physicochemical and microbiological analysis and were taken to the Microbiology research laboratory of Bayero University, Kano for further analysis. In line with standard procedures as described by Dem, (2007), the samples were sieved through a pore size of 0.5mm brass sieve and was done inside safety cabinet chamber and stored at room temperature for further analysis.

Determination of the selected soil physicochemical property

Temperature

The temperature of the soil was taken using mercury-in-bulb thermometer at each point of collection during sampling. This was achieved by dipped the thermometer 5-10cm depth and waited for 2-3 minutes and the reading was recorded.

Soil pH

A soil: water ratio of 1:2 was used. A 10g of soil was suspended in to 20ml of distilled water and a digital pH meter model EQ-610 was immersed in to the suspension and waited for seconds and the result was recorded as employed by Onyeike and Osuji (2003).

Moisture content

The laboratory determination of the moisture content of soil samples was carried out by placing 10g of soil sample in a weighing glass beaker initially weighed, followed by oven dried at 70°C for 24h. Glass beaker contained the dried soil were then be weighed again to get the final weight of the soil. The moisture content was calculated as percentage using the formula as described by ASTM, (2010).

Water Holding Capacity (WHC)

Water Holding Capacity (WHC) of the soil was determined by placing 3g of soil samples on a piece of Whatman filter paper which had been initially weighed, followed by oven drying at 70°C for 24h. Oven-dried soil on the weighed Whatman filter paper was dipped and saturated. The soil was then placed in humid enclosure to drain off the water and weighed again, and finally calculated using the formula below (ASTM, 2010).

$$\text{Water Holding Capacity (WHC)}: = \frac{\text{mass of water contained in saturated soil}}{\text{Mass of saturated soil}} \times 100$$

Organic matter

The soil organic matter was determined by Walkley-Black Wet Oxidation Method adopted by Eno, *et al.* (2009).

Soil texture

The texture of the soil was determined by the hydrometer method for the mechanical analysis of particle size distribution employed by Gee and Bauder (1986) was used.

Enumeration of the Total Aerobic Bacterial Plate Count in Herbicide Cultivated Soil Samples

A Nutrient Agar (NA, Oxoid) medium supplemented with 0.1g/L cyclohexamide specific media was used and were prepared according to the manufacturer's instruction.

A twenty five gram (25g) of herbicides treated and control soil samples from uncultivated site were weighted aseptically in to a conical flask containing 225ml of sterile distilled water. A homogenizer was used for proper mixing. Serial dilutions of up to 10^{-5} fold were prepared by transferring 1ml from stock solution in a test tube containing 9ml of sterile distilled water. A 0.1ml of 10^{-5} dilution of each suspension were plated aseptically using spread plate method on the prepared nutrient agar. The plates were prepared in triplicates, covered and dried. After 1h, the plates were inverted and sealed with parafilm to avoid contamination and incubated at 37°C for a period of 24 hours. After incubation the colonies were counted and expressed as colony forming unit per/g. The isolates obtained were sub cultured and the pure bacterial colonies were slanted and stored in the refrigerator at 4^0C (Odetunde *et al.*, 2014).

Isolation, Characterization and Identification of Bacteria from Herbicide Cultivated Soil Samples

A pure isolates obtained were subjected for the following identifications techniques.

Gram Staining: This technique was used to determine the nature of the bacterium. Colonies grown on nutrient agar was gram stained as per the procedure explained by Todar *et al*., (2005). **Motility Test:** Bacterial motility was done by hanging loop method. Few drops of liquid culture were place onto the cover slip in sterile condition. Depression slide was taken and the concave portion over the drop was pressed on the slide onto the cover slip. The slide was inverted quickly to keep from disrupting the drop. Then the motility was examined under microscope at 40× magnification Todar *et al*., (2005).

Biochemical Tests: Biochemical test such as indole test, methyl red test, citrate utilization test, voges proskauer test, catalase test, Oxidase and Urease test was carried out for the identifications of the isolates as adopted by Musliu and Salawudeen, (2012).

RESULTS

Selected Physicochemical Properties of the Soil Samples for the four sampling sites

Table 1 shows the result for the selected physicochemical properties of the soil sample at different sampling site of the ginger research farm. The temperature of the sampling point A and C had the highest average value of 40.0°C each and point B and control point D had 39.0°C respectively. Point A had the highest pH of 6.59 and point D with least of 5.99. In case of moisture contents point B had the highest value of 0.280% with the least water holding capacity of 60.67%. Point D had the least moisture contents 0.225 but with 65.43% water holding capacity while A had the highest water holding capacity of 67.57% with 0.229 moisture contents. However, the textural class for all the four point were sandy loam soil table.

Table 1: Physicochemical properties of soil sample for the four sampling sites

		Sampling	**Site**		
Parameter	A	B	C	D (Control)	Standard limits
Temperature	40.00	39.00	40.00	39.00	<40°C*
pH (H_2O)	6.59	6.45	6.53	5.99	6.0-9.0*
Moisture contents (%)	0.229	0.280	0.231	0.225	
Water Holding capacity	67.57	60.67	64.10	65.43	
Organic Matter (%)	1.878	1.88	1.769	1.996	0.5% – 3.0%*
Sand (%)	62	59[a]	61	60	
Silt (%)	23	24	19	24	
Clay (%)	15	17	20	16	
Textural class	Sandy loam	Sandyloam	Sandy loam	Sandy loam	

Statistically not significant p>0.05 (P=0.14) , FEPA (1991).

Average Bacterial Colony Forming Unit per Gram (cfu/g) of Soil for the four sampling site

Table 2 shows the result of mean bacterial colony forming unit per gram (cfu/g) of soil samples analyzed. The results from the table indicates that point D had the highest counts with 2.7 $\times10^6$ followed by point B with 1.6×10^6 and the lowest counts were recorded in point A and point C with similar average of 1.4×10^6 respectively.

Table 2: Average Bacterial Colony Forming Unit/Gram (cfu/g) of Soil samples for the four Sampling sites

Sampling site	CFU/G	Fertility level
A	1.4×10^6	1O^6 - 10^8cfu/g FAO, 2016
B	1.5×10^6	
C	1.4×10^6	
D	2.7×10^6	

Statistically not significant p>0.05 (P=0.081)

Morphological and Biochemical Properties of the Different Bacterial Isolates

Table 3 shows the morphological and biochemical properties of the different bacterial isolates. This shows that six bacterial isolates were identified and characterized based on the differences on their morphological and biochemical properties and the bacterial isolates were identified are *Proteus mirabilis, Staphylococcus sp., Micrococcus sp., Staphylococcus sp., Bacillus sp.* and *Enterobacter sp.*

Table 3: Morphological and Biochemical Properties of Different Bacterial Isolates

Lab. Code	Morphology /Arrengement.	Endo Spore	Motility	Grams test	Catalase	Oxidase.	Citrate.	Voges Proscour	Methyl Red	Urease.	Indole.	Expected Bacteria
1	Rod/ Single	−	+	−	+	−	+	−	+	+	−	*Prpteus. sp.*
7a	Coccus/irre. Clusters	−	−	+	+	−	+	+		+	−	*Staphylococcus sp.*
5	Coccus/clusters	−	−	+	+	+	+	+		+	−	*Micrococcus sp.*
8	Coccus/irre. Clusters	−	−	+	+	−	−	+		+	−	*Staphylococcus sp.*
7	Rod/pairs,chain	+	+	+	+	−	+	−		+	−	*Bacillus sp.*
16	Rod/ Single	−	+	−	+	−	+	+	+	+	−	*Enterobacter sp.*

DISCUSSION

The present research shows that physicochemical properties of the soil, aerobic bacterial counts and the predominant bacteria presents

The selected physicochemical properties of the soil sample of different site was determine in order to come up with the differences or similarities that exist in the site. From the results obtained the temperature of the site A and C with the average value of 40.0 respectively, site B and D had 39.0 and there is no statistically significant between the sampling sites (P > 0.05) and this may be due to the fact that they have similar ecological factors and the temperature range for the sites are within the standard limit of <40°C according to FEPA (1991). Site A had the highest pH of 6.59 and site D with least of 5.99. In case of moisture contents B had the highest value of 0.280 with the least water holding capacity of 60.67. Site D had the least moisture contents 0.225 but with 65.43 water holding capacity while A had the highest water holding capacity of 67.57 with 0.229 moisture contents and both the pH and moisture contents are within the standard limit of 6.0 – 9.0 and 0.5% – 3.0% respectively FEPA (1991). However, the textural class for all the four sampling points were sandy loam soil.

The enumeration of soil bacterial counts was carry out and the average counts were 2.7×10^6, 1.6×10^6cfu/g, 1.4×10^6cfu/g and 1.4×10^6cfu/g for point D (control), point A, B and C respectively even though there was no statistically significant differences between the points (p=0.081) but the little differences that exist between point D and the remaining three sites was due to the fact that the three points ABC had the history of herbicides applications while point D (control) is a virgin land. These findings are in consistent with the works by Ubuoh, *et al*. (2012) that applications of pesticides result in decline of the bacterial population which further stressed the soil the bacterial *species* present in the soil which will invariable reduce the action of bacteria in the soil that might lead to decline in soil fertility in the farmland. And persist in the soil for long usually affect soil resulting to chemical degradation of the soil (Kamrin, 1997; Gupta, 2001). However, the results of this study shows that 10^6 bacterial colony forming unit per gram of soil which are within the range of 10^6 -10^8cfu/g culturable bacteria present per gram of soil would be considerd a healthy number and number less than 10^6cfu/g indicates poorer soil health (FAO, 2016) which may be due to a lack of nutrients as food in low organic matter soil, abiotic stress imposed by extreme soil pH values (pH< 5 or > 8) or toxicity imposed by organic and in organic anthropogenic contaminants and in lines with works by Stanley, *et al*. (2013) that enumerates and identified numerous microorganisms in the soil which includes Proteus species and Actinomycetes which were sensitive to herbicides application and therefore, may serve as a reliable indicator of the biological value of soil.

Six different bacterial isolates were isolated, identified and characterized based morphological and biochemical properties. The bacterial isolates were characterized are both gram positive and gram negative bacteria with the predominant of gram positive. The gram positive bacteria are, *Staphylococcus sp.*, *Micrococcus sp.*, *Staphylococcus sp.*, *Bacillus sp.* and gram negative bacteria are *Proteus sp.* and *Enterobacter sp*. The presents study is in agreement with Stanley, *et al*. (2013) works on the effect of two herbicides, atrazine and paraquat on soil bacterial population with the predominant of gram positive *Bacillus species* and *Micrococcus species* and with less observed of gram negative species of *Proteus* and *Pseudomonas* bacterial. However, the predominant species of *Bacillus* and *micrococcus* respectively were isolated by Ubuoh, *et al*., (2012) on the research conducted on the effects of pesticide application on soil microbial spectrum: case study fecolart demonstration farm, Owerri-west, Imo State, Nigeria. But the present research is in contrast with the Benslama and Boulahrouf, (2013) works on isolation and characterization of glyphosate degrading bacteria from different soils of Algeria were isolated gram negative species of *Pseudomonas*, *Enterobacter*, *Serratia*, *Rahnella* and *Escherichia.* Conclusively, this study shows that use of herbicides applications at field recommended rate may not have an adverse effects on the bacterial load.

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Comparative Therapeutic Phytoconstituents of *Senecio biafrea* (Oliv. and Hiern) J. Moore and *Vernonia amygdalina* Del.

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KEYWORDS

Senecio biafrea,
Vernonia amygdalina,
Phytoconstituents,
Therapeutic,
Flavonoid

ABSTRACT

The therapeutic chemical constituents' investigation of Senecio biafrae shoot and Vernonia amygdalina leaf, which are commonly used in the Nigerian ethnomedicine, were studied. Phytochemicals viz: cardiac glycosides, tannin, cyanogenic glycosides, flavonoid, alkaloid and saponin in the dried powdered plants samples were analysed quantitatively by spectrophotometric and titrimetic methods. In the results, cardiac glycoside was the most abundant in V. amygdalina (8.79 ± 0.02 mg/g [or 57.1 %]) and S. biafrae (6.07 ± 0.07 mg/g [or 42.24 %]), with the former significantly ($P<0.01$) higher. Flavonoid (5.79 ± 0.08 mg/g [or 28.3 %]) and tannin (0.47 ± 0.02 mg/g [or 3.1 %]) contents in V. amygdalina were higher in comparison with the flavonoid (3.55 ± 0.01 mg/g [or 24.70 %]) and tannin (0.28 ± 0.01 mg/g [or 1.95 %]) in S. biafrae. The alkaloid in S. biafrae (4.1 ± 0.04 mg/g [or 28.53 %]) was higher in comparison with that of V. amygdalina (0.1± 0.01 mg/g [or 0.6 %]). The cyanogenic glycosides (0.26 ± 0.006 mg/g [or 1.81 %]) in S. biafrae was more in comparison with that of V. amygdalina (0.12 ± 0.02 mg/g [or 0.3 %]). The saponin content of V. amygdalina (0.13 ± 0.04 mg/g [or 0.6 %]) and S. biafrae (0.11 ± 0.03 mg/g [or 0.77 %]) were relatively low with no significant difference. However, the presence of these therapeutic secondary metabolites in S. biafrae and V. amygdalina supports their uses in the herbal preparations for the treatment of some diseases like malaria, diabetes and infertility in Nigeria.

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INTRODUCTION

All over the world, vegetables have been used for many years in daily life to treat diseases (Krishna *et al*., 2022). More than three-quarters of the world's population depend on complementary and alternative vegetable-based medicine for health care (Edirne, 2010). The healing potential of vegetables has been attributed to their therapeutic chemical constituents known as phytochemicals. Phytochemicals like cardiac glycosides, alkaloid, flavonoid and saponin play active roles in amelioration of diseases (Edeoga, 2005). They have been found to possess antidiabetic, antioxidant, antimicrobial, cancer preventive and antimalaria activities (Ajaiyeoba *et al*., 2006 Tanimowo *et al*., 2009; Osiyemi *et al*., 2013). However, the levels of these plants chemicals may vary depending on specie and variety (Onyeka *et al*., 2007).

Senecio biafrae and *Vernonia amygdalina* are vegetables in Asteraceae family. S. biafrae grows as undercover in tree crop plantation. It is a perennial climbing herb, with stem up to 3 m long, strongly branched; branches succulent and glabrous. Leaves alternate, simple or deeply pinnately lobed, more or less succulent (Bello *et al*., 2018). Its common name is "English spinach", also called "worowo" and "Ota eke" by the Yorubas and the Igbos, respectively in Nigeria (Odugbemi, 2006). It is cultivated as vegetable on a small scale, mainly in Nigeria and Cameroon. S. biafrae is known for its therapeutic virtues, notably among the Yoruba speaking people of South-western Nigeria where its leaf extract is used to stop bleeding from cuts or injury (Adelakun *et al*., 2018) and for the treatment of diabetes or pulmonary defects (Adebayo, 2009). It is used in traditional medicine to treat many other diseases such as oedema, cough, infertility, sore eyes and rheumatic pain in Benin, Côte d'Ivoire and Cameroon (Adebooye, 2004). *V. amygdalina* is a small shrub that grows in the tropical Africa with petiolate leaf of about 6 mm diameter and elliptic shape. It is commonly called "bitter leaf" and "ewuro" by the Yorubas. The plant has being used traditionally to treat malaria and gonorrhea in Nigeria and Uganda (Shaa *et al*., 2011), diabetes, kidney disease, jaundice, ascaris and stomach discomfort (Odugbemi *et al*., 2007). Hence, this study aims to estimate and assess the phytochemical contents in *S. biafrae* and *V. amygdalina* for justification of their folk claims as medicine.

MATERIALS AND METHODS

Plant Collection and processing

Senecio biafrae shoot and *Vernonia amygdalina* leaves were collected in Ibadan, Oyo state, Nigeria. The plants were authenticated in the Forestry Herbarium Ibadan (FHI) and a voucher specimen deposited there. The plants materials were air dried and ground into powder.

Quantitative analysis of phytochemicals

Determination of alkaloids

The alkaline precipitation gravimetric method (Harborne, 1998) was utilized. In brief, five grams (5 g) of the grind plant sample was added to 200 mL of 10% acetic acid solution in ethanol. The mixture was extracted for 4 hrs. at 28ºC and later filtered. The filtrate was reduced to one quarter of its original volume by evaporation on a water bath. Concentrated ammonium hydroxide was added to the extract in drops until alkaloid was precipitated. The alkaloid precipitate was collected in a weighted filter paper, washed with 1% ammonia solution and dried in the oven at 80ºC. Alkaloid content was determined and expressed as a percentage of the weight of sample analyzed (Obadoni *et al*., 2001).

Determination of cardiac glycosides

The protocol of El-oleny *et al*., (1994) using Buljet's reagent (95 mL aqueous picric acid + 5 mL 10% aqueous NaOH) was used to evaluate cardiac glycosides in the plant sample. One gram of the pulverised plant sample was macerated in 100 mL of 70% alcohol for 2 hrs. and then filtered. Thereafter, the extract was then purified with lead acetate and Na_2HPO_4 solution before the addition of freshly prepared Buljet's reagent. The intensity of the colours produced was then measured using a spectrophotometer at 495 nm. The difference between the intensity of colours of the experimental and blank (distilled water and Buljet's reagent) samples shows the absorbance which is proportional to the concentration of the glycosides.

Determination of tannin

One gram (1 g) of the fine powder sample was measured into a beaker. The sample was soaked with solvent mixture (80 mL of acetone and 20 mL of glacial acetic acid) for 5hrs. to extract tannin. The mixture was filtered and set of standard solution of tannic acid was prepared ranging from 10ppm to 50 ppm. The absorbances of the standard solutions as well as that of the filtrate were read at 500 nm on a spectrometric 20. The percentage tannin was calculated.

Determination of total flavonoid content

The total flavonoid content was done by using the methodology of Sakanaka *et al*., (2005). 1 mL of the plant extract or + (catechin standard solution (50-250 mg/mL was added to 5 mL of distilled water in a test tube. 0.3 mL of a 5% (w/v) sodium nitrite solution was also added and the mixture was left for 6 mins. Thereafter, 0.6 mL of 10% (w/v) $AlCl_3.6H_2O$ solution was added and the mixture was allowed to stand for a further 5min. before 2 mL of 1M NaOH was added. The mixture was made up to 10 mL with distilled water and mixed well. The absorbance was determined immediately at 510 nm values of triplicate analysis were expressed as mg of (±) catechin equivalents per gram of total extractable compounds.

Determination of saponin

A weight 2 g of powdered plant sample was measured into a 250 mL beaker and 100 mL of isobutylacohol (octanol) was added and left for 5 hrs. on a shaker. The mixture was then filtered using a No. 1 whatman filter paper. The filtrate is transferred to another 100 mL beaker and saturated with magnesium carbonate solution. The mixture obtained here was then filtered to obtain a clear colourless solution. This was read on a spectrophotometer at 380 nm. 0 ppm -10 ppm of standard saponin solutions were prepared from 1000 ppm saponin stock standard solution and saturated with magnesium carbonate as above which was also filtered. The absorbances of the saponin standard solutions were also read at 380 nm to obtain the gradient of plotted curve.

Determination of cyanogenic glycosides

A weighed quantity (5 g) of the powdered plant sample was dispensed into 250 mL conical flask. The sample was incubated for 16hrs. at 38ºC. After, it was extracted with 95% methanol and filtered using double layer of hardened filter paper. Distillation was done with Marharm distillation apparatus. The sample extracted was transferred into a tow-necked 500 mL flask connected with a steam generator. This was steam distilled with saturated sodium bicarbonate solution contained in a 50 mL conical flask for 60 minutes. 1 mL of starch indicator was added to 20 mL of each distillate and was titrated with 0.2N of iodine solution. The percentage hydrocyanide was calculated.

Data analysis

All tests were carried out in triplicate and the Microsoft Excel 2007 was used to compute mean and standard deviation (SD). The student t-test was used to compare the means and values of $P \leq 0.05$ were considered significant. Results were expressed as mean ± SD and relative percentage of mean.

RESULTS AND DISCUSSION

Reorientation on the choices of plant-based foods consumed has become essential for humans overall wellness. Consumption of sufficient plant-based foods like vegetables could be an important measure towards it. However, certain vegetables posses more significance quantity of therapeutic phytoconstituents than others as they boost immunity and treat diseases. Thus, daily intake of vegetables with sufficient therapeutic phytoconstituents is *sine qua non*. The therapeutic properties of vegetables are attributed to the presence of certain phytoconstituents like cardiac glycosides, tannin, cyanogenic glycosides, flavonoid, alkaloid and saponin.

Table 1: Mean weight (mg/g) of the phytochemicals in *S. biafrae* shoot and *V. amygdalina* leaf

Phytochemicals	***S. biafrae***		***V. amygdalina***	
	Mean and standard deviation (mg/g)	**Relative % of mean**	**Mean and standard deviation (mg/g)**	**Relative % of mean**
Alkaloid	4.1 ± 0.04**	28.53	0.1± 0.01**	0.6
Cardiac glycosides	6.07 ± 0.07**	42.24	8.79 ± 0.02**	57.1
Tannin	0.28 ± 0.01*	1.95	0.47 ± 0.02*	3.1
Saponin	0.11 ± 0.03	0.77	0.13 ± 0.04	0.8
Flavonoid	3.55 ± 0.01**	24.70	5.79 ± 0.08**	37.6
Cyanogenic glycosides	0.26 ± 0.006**	1.81	0.12 ± 0.02**	0.8
Total	14.37	100	15.4	100

**P* < 0.05, ***P* < 0.01

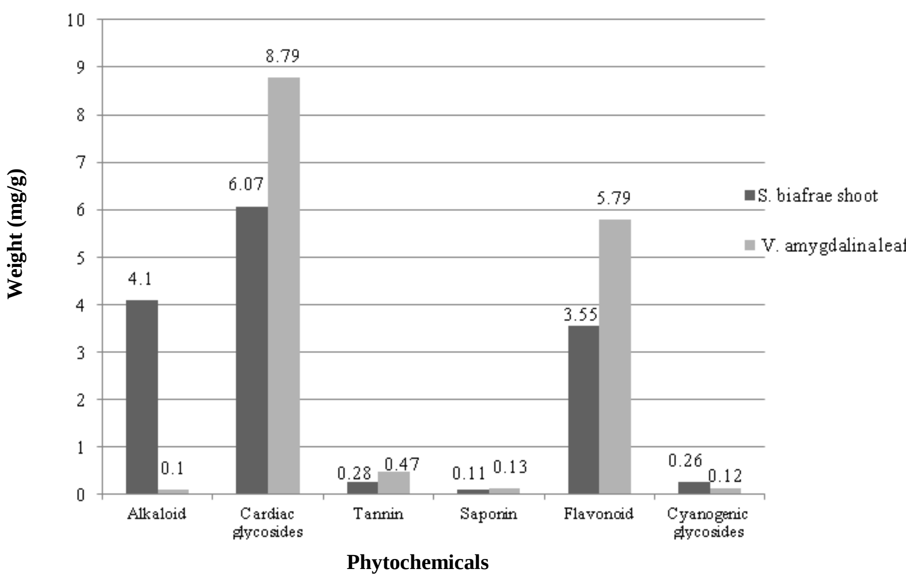

Figure 1: Comparative weights of some phytochemicals in *S. biafrae* shoot and *V. amygdalina* leaf

The results of work done on the vegetables in Figs. 2 and 3 showed that cardiac glycosides was the most abundant in *V. amygdalina* (8.79 ± 0.02 mg/g [or 57.1 %]) and *S. biafrae* (6.07 ± 0.07 mg/g [or 42.24 %]), with the former significantly (P<0.01) higher (Table 1). Cardiac glycosides belong to steroid-sugar hybrids, usually used for the treatment of cardiac failure (Hou *et al*., 2021) and also exhibit excellent anticancer activity (Wang *et al*., 2014). Cardiac glycosides from *Streptocaulon juventas* (Apocynaceae) inhibit HepG2 cell growth proliferation (Zhu *et al*., 2018), and the one from *Impatiens glandulifera* (Balsaminaceae) was active against A549, U373 and SKMEL-28 cancer cell lines (Cimmino *et al*., 2016).

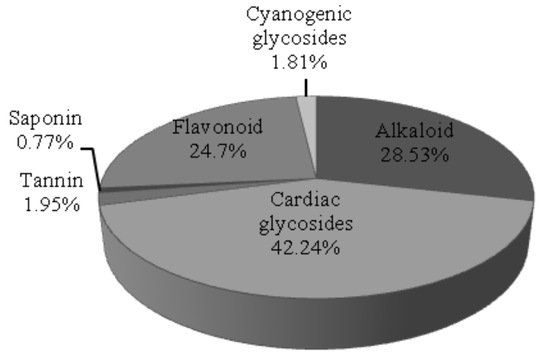

Figure 2: Relative percentages of some phytochemicals in *S. biafrae* shoot

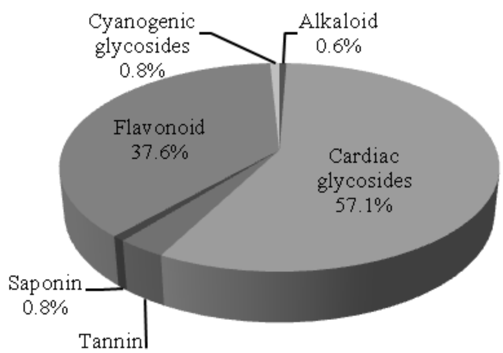

Figure 3: Relative percentages of some phytochemicals in *V. amygdalina* leaf

Flav *dalina* are significantly ($P<0.05$) higher in comparison with the flavonoid (3.55 ± 0.01 mg/g [or 24.70 %]) and tannin (0.28 ± 0.01 mg/g [or 1.95 %]) in *S. biafrae.* It has been revealed that the average intake of flavonoids by humans on a normal diet is estimated at 650 mg per day (Liu, 2013). Myriads of studies have reported the bioactivities of flavonoid compounds to include antioxidant, anti-inflammatory, antiallergic, anticancer, cardioprotective and anti-diabetic activities (Karak, 2019; Fallah *et al*., 2020). Moreover, it was shown that flavonoids were quite efficient in obesity prevention and weight control (Akhlaghi *et al*., 2018). Plant tannins are polyphenolic substances with beneficial effects for controlling chronic disorders particularly diabetes mellitus (Mohammed and Mohamed, 2019). Thus, the presence of flavonoid and tannin in these vegetables warranted their folk use especially as antioxidant and antidiabetic. *V. amygdalina* contains flavonoid, about 2 times more than that in *S. biafrae* (Fig. 1). This observation tends to indicate the more free radical scavenging effect of the former.

The alkaloid in *S. biafrae* (4.1 ± 0.04 mg/g [or 28.53 %]) was significantly ($P<0.01$) higher than in *V. amygdalina* (0.1± 0.01 mg/g [or 0.6 %]). Plant alkaloids have played a key role in traditional medicines as sedatives, antitussives, purgatives, and treatments for a wide variety of ailments (Gutiérrez-Grijalva *et al*., 2020). Currently, several alkaloids have served as templates for modern drugs, and there are several alkaloids used in pharmacology, such as codeine, brucine, morphine, ephedrine, and quinine (Aniszewski, 2015)

The cyanogenic glycosides (0.26 ± 0.006 mg/g [or 1.81 %]) in *S. biafrae* is significantly ($P<0.01$) more in comparison with that of *V. amygdalina* (0.12 ± 0.02 mg/g [or 0.3 %]). Cyanogenic glycosides are leading toxins (Vetter, 2000), their concentration is often higher in seedlings and young leaves than in mature plants (Nahrstedt, 1985). Cyanogenic glycosides have been reported to cause adverse health effects in humans, e.g., irreversible paralytic disorder, neurosensory deafness, and goiter (Chikezie *et al*., 2015). From this present study, the cyanogenic glycosides content of *S. biafrae* shoot was a little more than the toxic dose (>0.2 mg/g) hence, consumers should take caution. Moreover, a cyanogenic glycoside, amygdalin, from *V. amygdalin* has been investigated as a potential anticancer agent (Barakat *et al*., 2020). Recent results have indicated a potential neuroprotective action of a cyanogenic glycoside, prunasin 2′,3′,4′,6′-tetra-O-gallate (Tan *et al*., 2012). In addition, applications of cyanogenic glycosides from *Cardiospermum* sp. in medicine against rheumatoid arthritis have been patented (Sun *et al*., 2017).

The saponin content of *V. amygdalina* (0.13 ± 0.04 mg/g [or 0.6 %]) and *S. biafrae* (0.11 ± 0.03 mg/g [or 0.77 %]) were relatively in trace (Figs. 2 and 3) with no significant difference (Table 1). The main health effects of saponins are serum cholesterol lowering, anticoagulant, cardiovascular protection and adjuvant (Singh and Chaudhuri, 2018). Moreover, saponins have a prominent advantage as they are needed in low dose for adjuvant activity (Rajput *et al*., 2007).

CONCLUSION AND RECOMMENDATION

The presence of the phytoconstituents revealed in *S. biafrae* shoot and *V. amygdalina* leaves accounted for the various medicinal claims on these vegetables for the treatment of infections and diseases. Such information may be encouraging for researchers to carry out further advanced research on plants with potential therapeutic properties, in order to give preference to their cultivation, consumption and sustainable conservation.

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Effects Of Pawpaw (*Carica Papaya*) Leaf Meals on Haematological and Carcass Characteristics of Broilers

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K E Y W O R D S

Broiler Carcass,
Leaf meal,
Haematology,
Pawpaw

A B S T R A C T

This study was designed to investigate the effect of varying levels of pawpaw leaf meal (PLM) on haematological and carcass characteristics of broiler birds. Sixty broilers of five weeks old were used for study which lasted for five weeks. The birds were assigned to four treatment diets with three replicates. The finisher rations were formulated in which PLM was incorporated at 0.5%, 1.5% and 2.0% in T_2, T_3 and T_4 respectively. T_1 had no PLM and served as the control diet. The diets were isocaloric and isonitrogenous containing 2,850kcal ME/kg and 20% crude protein. At the end of the experiment, data collected on haematological and carcass characteristics were subjected to analysis of variance (ANOVA) a completely Randomized Design (CRD). Results showed that there were significant ($p < 0.05$) improvements on the haematological and carcass characteristics of birds fed the treatment diets. Birds on T_4 diets had ($p < 0.05$) better haematological profiles Hb (10.17%) and PCV (31%) as against the control diet of Hb (8.09%) and PCV (25.97%). The carcass characteristics of the birds followed similar trend in which T_4 had significant higher values of 2,168g and 73.90% for dressed weight and dressed % respectively. While T_1 (control) had the lowest values of 1,786g and 68.96% for dressed weight and dressed% respectively. It is concluded that incorporating 2.0% PLM (T_4) into the diets of broilers helped to improve the haematological responses.

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INTRODUCTION

High cost of feed arising from the general unavailability of feedstuff or high cost of feed ingredients especially protein sources have resulted in drastic decline in productivity and profitability for intensive broiler production system. This scenario has resulted in supply bottlenecks forcing an upsurge in the price of broiler products in Nigeria. It is in realization of the above that farmers and feed manufacturers are now adjusting their operations towards exploring locally available and cheap feedstuff (Bratte *et al*., 2011) that are not readily utilized by man and the industries and stand as the only viable alternative to conventional feed ingredients (Mohammad, 2021).

The proteins from the leaves may be recovered and fed to farm animals in form of leaf meal protein concentrates. Examples of the leaf meals which have been widely used in feeding non-ruminant animals include *Leucaena leucocephala, Azadirachyta indica, Gliricidia sepium, Carica papaya* and *Manihot esculenta* (Gadzirayi *et al*., 2012; Onyimonyi and Onu, 2009) and also provides some necessary vitamins, minerals and oxycarotenoids which cause yellow colour of broiler skin, shank and egg yolk (Onyimonyi and Onu, 2009; Esonu *et al.*, 2006). The only perceived constraints of using leaf meal are the presence of some phytochemicals and anti-nutrient factors commonly found in plants which could limit digestibility though these could be alleviated through different processing methods.

However, it becomes imperative to investigate the haematological indices of the broilers fed pawpaw leaf meal to further ascertain the safety of its use. Pawpaw plant has been identified and used in herbal applications and as ethnobotanical in feeding of finishing broilers (Onyimonyi and Onu, 2009). This research was therefore, designed to investigate the haematological and carcass characteristics of finishing broilers fed varying dietary levels of pawpaw leaf meal.

METHODOLOGY

Experimental Location and Animal Management

The experiment was conducted at the poultry unit of the Teaching and Research Farm of the Faculty of Agriculture, University of Nigeria, Nsukka. A total number of 60 broiler chicks of Anak strain were used for the experiment. The chicks were brooded in a deep litter system for four weeks and were transferred into individual pens measuring 4 x 5feets. Feed and water were provided ad-libitum with appropriate routine medications and vaccinations.

Preparation of Test Ingredients and Experimental Diets

The pawpaw leaves (*Carica papaya*) used for this experiment were harvested from the pawpaw trees plantation of the Department of Crop Science, University of Nigeria Nsukka. The leaves were harvested and dried at the greenhouse unit of the Department of Crop Science. The greenhouse has a temperature range of 30-40C in the afternoon but lower than this in the morning and evening hours. The pawpaw leaves were allowed to stay for 2-3 days at the greenhouse for it to dry to crispy while still retaining its greenish colouration the dried leaves were milled using the milling machine at the Department of Crop Science Analytical Laboratory to produce pawpaw leaf meals (PLM). The leaf meal was further subjected to proximate analysis to determine the crude protein content.

Experimental Design and Data Collection

The experimental design used was a completely randomized design (CRD). After brooding for four weeks, the birds were randomly allotted to the four (4) experimental groups with 15 birds each, replicated 3 times to give 5 birds per replicate. The treatment effect was estimated by comparing the means of the assessed parameters in the treated groups against the control.

At eight weeks old, one bird was randomly selected from each replicate, isolated, tagged and starved overnight. The blood samples were drawn for haematological tests from the jugular veins (Alcorn, 2002). The samples were taken in labeled sterile universal bottles containing ethylene diamine tetra-acetic acid (EDTA) and were used to analyze for full blood count.

Heamatological Determination

In heamatological determination, the Haemoglobin concentration (Hb) was determined using the method as described by Drabkin 1932 while Red blood cell (RBC) was determined using the methods as described by Sood, 2006. White Blood Cell (WBC), Packed Cell Volume (PCV), were determined using the method as described by Baker and Silverton (1985). Thereafter, the Mean Cellular Volume (MCV) Mean Cellular Haemoglobin Concentration (MCHC), and Mean Cellular Haemoglobin (MCH) were calculated from red blood cell. In carcass characteristics, the following parameters were collected; Live weight (g), Dressed weight (g), % Dressed weight, % Head weight, % Neck weight, % Breast weight, % Wing weight, % Thigh weight and % Shank weight,

Statistical Analysis

The data collected were subjected to analysis of variance (ANOVA) using SPSS version 21. Means were separated using Duncan's option as found in statistical package /software (Duncan, 1955)

Table 1. Percentage Composition of the Finisher Diets

Ingredients	T1(control)	T2(0.5%)	T3(1.5%)	T4(2.0%)	PLM
Cassava chips	40	40	40	40	--
Maize	7	7	7	7	--
Groundnut cake	25	24.5	23.5	23	--
Palm kernel cake	19	19	19	19	--
Pawpaw leaf meal	0	0.5	1.5	2.0	--
Fish meal	5	5	5	5	--
Bone meal	3	3	3	3	--
Salt	0.25	0.25	0.25	0.25	--
Lysine	0.25	0.25	0.25	0.25	--
Methionine	0.25	0.25	0.25	0.25	--
Vit premise	0.25	0.25	0.25	0.25	--
Total	100	100	100	100	--
Determined Analysis					
Moisture	12.20	11.00	12.80	10.20	10.20
Crude Protein	20.66	21.37	21.42	21.16	30.12
Crude Fibre	4.90	5.12	5.27	5.38	5.60
Ether Extract	1.10	1.20	2.0	1.40	1.20
Ash	10..03	10.02	1..49	10.62	8.45
Nitrogen Free Extract	52.01	51.29	48.52	51.99	44.43

Provided the following per kg of feed: vitamin A, 10,000iµ; vitamin D2, 2000iµ; vitamin E, 6iµ; vitamin K, 2mg; riboflavin, 4.2 mg; vitamin B12, 0.01mg; pantothenic acid, 5mg; nicotinic acid, 20mg; folic acid, 0.5mg; choline, 3mg; Fe, 20mg; Mg, 56mg; Cu, 1.0mg; Zn, 5.0mg; Co, 1.25mg; Iodine, 0.8mg.

Table 2: Haematological Indices of Broilers Fed Pawpaw (*Carica papaya*) Leaf Meal

Parameters	T1	T2	T3	T4	SEM
PCV (%)	25.97^b	26.27^b	29.97^a	31.00^a	0.40
Haemoglobin (g/100ml)	8.09^b	8.48^b	9.46^a	10.15^a	0.53
Red Blood Cell (mm^3)	3.43	3.97	4.23	4.27	0.21
Total WBC x $10^6 mm^3$	4.27^b	4.50^b	5.40^a	5.37^a	1.05
TWBCDIFF					
Neutrophils (%)	14.60	12.70	13.30	12.50	0.63
Monocytes (%)	4.10	4.80	4.60	4.30	0.21
Lymphocytes (%)	81.30	82.50	82.10	83.20	1.38
MCV (fl)	101.30^c	112.10^b	116.40^b	125.40^a	1.76
MCH (g/dl)	33.80	34.70	33.60	32.60	1.13
MCHC (%)	41.60	40.90	42.40	43.30	0.82

PCV = packed cell volume; MCV=mean corpuscular volume; MCH=mean corpuscular haemoglobin; MCHC= mean corpuscular haemoglobin concentration

Table 3: Carcass Characteristics of Broilers Fed Pawpaw (*Carica papaya*) Leaf Meal

Parameters	T1(Control)	T2(0.5%)	T3(1.5%)	T4(2.0%)	SEM
Live Weight (g)	$2,600^c$	$2,750^b$	$2,800^b$	$2,950^a$	1.27
Dressed weight (g)	$1,786^c$	$1,946^c$	$1,986^b$	$2,168^a$	1.72
Dressing %	68.69^c	70.76^b	70.93^b	73.90^a	0.89
Breast %	27.24	27.86	28.14	28.78	0.38
Thigh %	20.63	21.48	21.32	21.78	0.32
Wings %	7.13	7.64	7.79	7.91	0.14
Shank %	4.16	4.62	4.24	4.54	0.12
Head %	2.50	2.46	2.67	2.69	0.10

RESULTS AND DISCUSSION

Haematological Indices

The results of the haematological indices of the broilers were presented in table 2. Hb, PCV, WBC and MCV were significantly ($p < 0.05$) affected by the treatment groups. Birds on T4 and T3 had similar ($p > 0.05$) PCV values of 31.00% and 29.97% which were themselves similar but different ($p<0.05$) from the values of 25.97% and 26.27% reported on T1 and T2 respectively. However, Hb and WBC followed the same trend in which T4 and T3 had higher significant values than T1 and T2. In MCV, T4 had the highest value of 125.40fl which was significantly ($p<0.05$) different from T3 (116.40fl) and T2 (112.10fl) which were themselves similar but different from the value of T1 (101.30fl).

In carcass characteristics of broiler chickens fed varying levels of pawpaw leaf meal, significant differences exist on their live weight, dressed weight and dressing percentage. Birds on T4 had the highest live weight of 2950g which was significantly ($p<0.05$) higher than the T2 (2750g) and T3 (2800g) which were themselves similar but different from T1 (Control) which had the lowest value of 2600g. The dressed weight and dressing percentage followed the same trend in which T4 had the highest values of 2,168g and 73.90% respectively while T1 had the lowest values of dressed weight gain and dressing percentage of 1,786g; 68.69% respectively.

Haematological indices of an animal plays a vital role in determining the physiological conditions of the farm animal, by distinguishing normal state from state of stress which could be nutritional, environmental or physical. As a suitable guide, a PCV value above 56% indicates that the birds are dehydrated, while PCV value below 22% is an indication that the birds are anaemic (Pendl, 2001) In the present study, all the PCV values were within the normal value for the birds of their size and age (25-45%) (Al-Nedawi, 2018).

However, the significant increase in Hb and PCV and numerical increase in RBC counts of the broilers fed PLM are an indication that the oxygen-carrying capacity of the blood was improved (Napirah *et al*., 2013; Revsianto, 2016).

Thus, haemoglobin range of 7.04 to 13.0g/dl reported by (Putriani *et al*., 2012) corresponds with the value of 8.09g/dl to 10.17g/dl obtained in this present study. However, the values obtained from this present study were higher than the value of 6.85g/dl to 7.40g/dl reported by (Sugiharto *et al*., 2015) and 5.18 to 9.30g/dl as submitted by (Salam, *et al*., 2013).

An increased value of MCV MCH and MCHC levels is an indication that the birds are not undergoing any serious stressors (Huff, 2006). It can be inferred therefore that the PLM may have slightly increased the bird's ability to withstand stress. This view agrees with the work of Esonu *et al*., 2006 who reported an improved performance of birds fed Neem (*Azadirachta indica*) leaf meal at different inclusion levels.

In carcass characteristics, the high breast percentage range of 27.24% -28.78% corresponds with the value obtained by (Egbunike *et al.,* 2009) but higher than the value of 21.77% - 24.90% reported by (Oladimeji *et al.,* 2020). Likewise, the value of 27.24% -28.78% obtained in this current study was higher than the earlier values of 23.04% - 24.73% report by (Ogunwole *et al*., 2016) when fed ϐ carotene cassava grit-based diets.

Generally, T4 had superior values in all the carcass parameters obtained in this study and this is an indication that the PLM, may have positively influenced the carcass yield of broilers fed the treatment diets. Pawpaw leaf contains high crude protein percentage and also papain which may have aided in digestion and in the release of free amino acids resulting in better performance as in this study.

CONCLUSION

Broiler finisher diet can be supplemented with pawpaw leaf meal at 2.0% with no adverse effects on haematological parameters and carcass characteristics. The positive influence of pawpaw leaf meal justifies the practice of using them in broiler production to help improve the health and general wellbeing of broiler chickens. It also aided in cost reduction and increased profit margins as a protein supplement in finishing broiler diets judging from the increased carcass meat yield as observed from the birds fed the treatment diets.

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Assessment of Open Grown Tree Species Diversity in Nnamdi Azikiwe University, Awka, Nigeria

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K E Y W O R D S

Open grown trees,
Conservation,
Species diversity,
Sustainability

* C O R R E S P O N D I N G A U T H O R

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A B S T R A C T

Trees, which are important for the sustenance of life and the health of our planet, are disappearing at an alarming rate. In Nigeria, the impacts of climate change will further aggravate the plights of many indigenous and exotic tree species as climatic variability may limit the ability of forest trees to quickly adapt to the changing climate. This study focused on the assessment of open grown tree species diversity in the Nnamdi Azikiwe University, Awka, Nigeria which is considered as a crucial task to design strong conservation action strategies. Open grown tree species with diameter at breast height (Dbh) ≥10 cm in the study area were identified and recorded. Data collected were analyzed using descriptive statistics and alpha diversity analysis. A total number of 479 trees distributed among 25 tree species and 17 families were identified, with high Shannon-Weiner diversity index (2.50) and Simpson dominance index (0.88). The study indicated high species variability within the study area with Fabaceae family having the highest diversity of 4 species. Other important families dominating the study area include Apocynaceae, Lamiaceae, Moraceae and Myrtaceae with same number (2) of species. The study concluded that there is a huge presence of indigenous and exotic tree species in the study area and some are no longer found in most natural forests underscores the potentials of the campus as an important live gene bank. The study therefore recommends the need for policy intervention to aid the identification, documentation and conservation of forest tree resources in the University.

INTRODUCTION

Trees, which are important for the sustenance of life and the health of our planet, are disappearing at an alarming rate. Over the years, trees had undergone different levels of disturbance due to unprecedented increase in human population, which have led to cutting of trees for firewood collection, charcoal production, and infrastructural developments (Omoro *et al.*, 2010). Consequently, the need for actions to develop effective strategies to conserve trees is receiving considerable attention worldwide. Forest genetic resources are fast becoming depleted in most natural forests due to the pressures of deforestation, urbanization, poor management and a regeneration program that is virtually nonexistent. To protect trees from declining, it is essential to examine the current status of species diversity, composition as it will provide guidance for their management and valuable reference for assessment**,** as well as improving our knowledge in identification of ecologically useful species (Suratman, 2012).

Overpopulation has resulted in the rapid loss of tree diversity and is recognized as a major environmental and economic problem around the world (Mani and Parthasarathy, 2006). An open grown tree is a tree that has grown virtually all its life without competition from other trees. The importance and conservation of the open grown tree as natural, cultural and literary icons (Spector *et al.*, 2006) is now gaining recognition across the world. Therefore, information on composition, diversity of tree species and species-rich communities is of primary importance in the biodiversity conservation efforts (Suratman, 2012). The trees of a community such as university campus can be used as its defining features. They define the landscape by their beauty and presence. Trees also help in the amelioration of the university environment. Therefore, trees within such areas require proper management and documentation of their characteristics.

Diversity of tree species simply means the different tree species that can be found or the various variety of tree species present in a particular given area. Diversity of tree species is measured through a combination of species richness (the number of species present) and species evenness (the abundance of each species). This information can be from a forest survey or from inventory data. Species diversity can be calculated at many scales, whether for a forest area, urban area, regionally or even nationally. Lafrankie *et al.* (2006) reported that**,** the tropical rainforests are vulnerable to deforestation and degradation. In Nigeria, population growth has led to an astronomical increase in anthropogenic activities, excessive logging and over exploitation. As a result, most of these forests have either been converted to farmland of arable and cash crops or other land uses.

Trees satisfy certain physiological and cultural needs of urban dwellers (Dwyer *et al.,* 1991). They play a social role in easing tensions and creating a serene environment that helps relax the minds of dwellers in the urban environment (Ulrich, 1990). The knowledge of the tree species diversity will enable inhabitants to positively relate with the trees as well as promote the diversity and sustainable management of the trees. Therefore, the aim of this study is to identify the diversity of open grown trees species found in Nnamdi Azikiwe University Awka, Nigeria.

MATERIALS AND METHODS

Study area: The study site is Nnamdi Azikiwe University Awka, Nigeria established in the southeastern zone in 1991 with mean elevation of 136 meters above sea level. It lies between the latitude 6.245° to 6.283° N and longitude 7.115° to 7.1219° E. The climate of the area is tropical indicating that it is basically within the tropical rainforest ecological zone with mean temperature of 26.3°C. Awka has seasonal climatic conditions; the rainy and the dry seasons with a short spell of harmattan as well as precipitation array of 1828 mm – 2002 mm (Ezenwaji *et al.,* 2013, Chukwu *et al.,* 2020). Figure 1 displayed the map of Awka South showing the location of the study area.

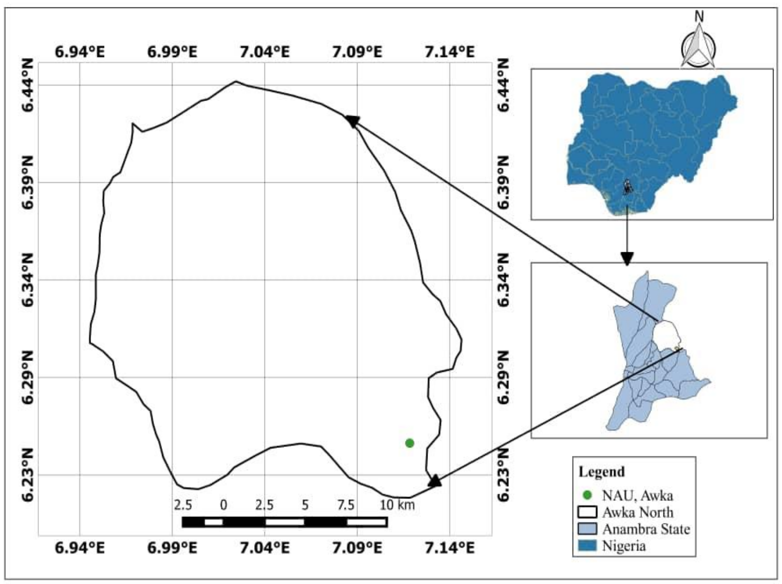

Figure 1: Map of Awka showing NAU.
Source: Ezenwenyi *et al.* (2020)

Data Collection and Sampling procedure

Field inventory of tree species was adopted for data collection. The study area was divided into two (sites A and B) for accurate recording of different trees species. Site A covered Faculty of Bio-sciences to Chike Okoli building and site B from Faculty of Environmental management to schools back gate. Using the main road as transect, sampling was done on both sides to enable accurate enumeration of all tree species. Through this survey, identification was limited to all the trees with diameter at breast height (Dbh) of ≥ 10 cm. These trees were identified at species level and recorded.

Data computation

Tree species Diversity: The following tree diversity indices were computed; Shannon – Wiener diversity index (H'), species evenness (E) and species dominance index to determine the tree species diversity.

Shannon – Wiener Diversity index (H'): The Shannon-Wiener diversity index is the most widely used index in community ecology. The values of Shannon – Wiener diversity index is usually found to fall between 1.5 and 3.5 and only rarely surpasses 4.5 (Magurran, 1998). It is given by

$$H' = -\sum_{i=1}^{s} P_i \ln P_i \qquad (1)$$

Where, H′ = Shannon-Weiner index, P_i= the fraction of individual belonging to the ith species, ln = natural log, i = 1, 2, . . ., s.

Simpson's dominance index

Simpson's dominance index is weighted towards the abundance of the commonest species.

$$\text{Simpson index (c)} = 1 - \sum_{i=1}^{m} P_i^2 \qquad (2)$$

Where, P_i = the proportional abundance of the ith species($P_i = \frac{n_i}{N}$), n_i = individual observation of ith species, N = Total number of all species, i = 1, 2, …, m

Data Analysis

Tree diversity and exploratory analyses: Alpha diversity method according to Magurran (2004) was used in the analysis of tree diversity for Shannon and Simpson indices while descriptive statistics (frequency, percentage, graphs etc.) was used in analyzing the species composition.

RESULTS

Identification and assessment of tree species composition

The results of tree species identified, their family and relative density (%) in the study area are presented in Table 1 and Figure 2. The total number of 25 tree species in 17 families were identified and recorded from this study area. *Azardirata indica* had the highest percentage of distribution of 26.1%. This was followed by *Vitex doniana* and *Daniella oliveri* with 10.0% and 9.6 % of distribution respectively. *Annona senegalensis, Holarrhena floribunda, Pentracletra macrophylla, Dalium guineense, Ficus capensis, Treculia africana* and *Carpolobia lutea* had the least and same value of percentage distribution of 0.2%. The number of species observed in each family as presented in Figure 2 showed that the family Fabaceae had the highest number (4) of species observed and they are *A. lebbeck* (4), *D. oliveri* (46), *P. macraphyla* (1) and *T. tetraptera*. This was followed by Apocynaceae, Lamiaceae, Moraceae and Myrtaceae all with same number of species observation of 2. Other families had only one (1) number of tree species observations.

Table 1: Tree species identified, their Families and percentage of occurrence in the study area

Family	Species	No of Tree	Percentage
Annonaceae	*Annona senegalensis*	1	0.2
Apocynaceae	*Alstonia boonei*	15	3.1
	Holarrhena floribunda	1	0.2
Arecaceae	*Borrassus aethiopum*	37	7.7
Bignoniaceae	*Newbouldia laevis*	39	8.1
Fabaceae	*Albizia lebbeck*	4	0.8
	Daniellia oliveri	46	9.6
	Pentaclethra macrophylla	1	0.2
	Tetrapleura tetraptera	5	1.0
Gentianaceae	*Anthocleista Schweinfurthii*	6	1.3
Lamiaceae	*Gmelina arborea*	25	5.2
	Tectona grandis	5	1.0
leguminosae	*Dialium guineense*	1	0.2
Longaniaceae	*Anthocleista vogelli*	16	3.3
Malvaceae	*Ceiba pentandra*	2	0.4
Meliaceae	*Azardirachta indica*	125	26.1
	Melicia excels	11	2.3
Moraceae	*Ficus capensis*	1	0.2
	Treculia Africana	1	0.2
Myrtaceae	*Eucalyptus camaldulensis*	32	6.7
	Eucalyptus globulus	20	4.2
Pinaceae	*Pinus caribaea*	32	6.7
Polygalaceae	*Carpolobia lutea*	1	0.2
Rubiaceae	*Morinda lucida*	4	0.8
Verbenaceae	*Vitex doniana*	48	10.0

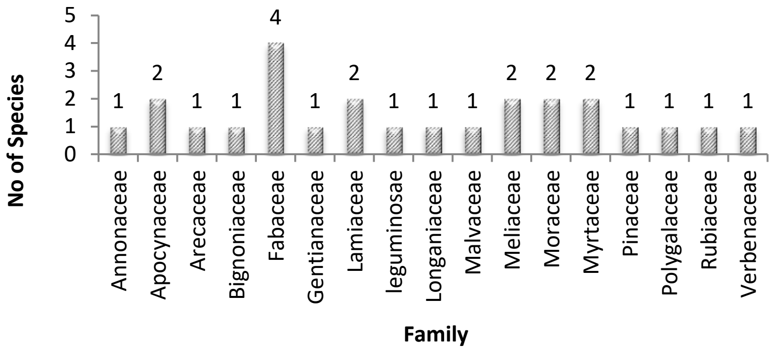

Figure 2: The number of species identified in each family

The graph (Figure 3) showing the frequency distribution of individual tree species observation according to their families revealed that, the family Meliaceae had the highest frequency of observation (136 trees); followed by Fabaceae and Myrtaceae of 56 and 52 trees respectively. Annonaceae, Leguminosae and Polygalaceae families had the least number of observations (1) each. The family and species of the trees encountered in the study area and their respective relative abundance (Pi), Simpson's dominance index and Shannon –Weiner diversity (H') are presented in Tables 2 and 3. The result of Shannon-Weiner diversity Index (H') for species diversity was 2.51 and this is greater than 1. Simpson index (C) value for species abundance was 0.88. Tree species diversity is one of the indicators of forest health. If H' <1, this implies that the tree diversity of the forest is low and vice versa. This simply means that the trees diversity of the study area is high because the result is >1.

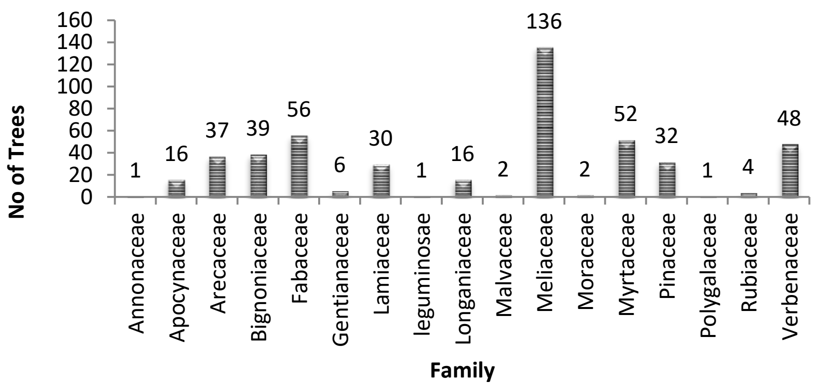

Figure 3: The frequency distribution of individual tree species according to their families

Table 2: Tree species diversity analysis

Sn	Family	Species	Frequency	Simpson's dominance Index	Relative Abundance (Pi)	LnPi	PiLnPi
1	Fabaceae	*Albizia lebbeck*	4	0.00007	0.00835	4.78541	0.03996
2	Apocynaceae	*Alstonia boonei*	15	0.00098	0.03132	3.46365	0.10847
3	Annonaceae	*Annona senegalensis*	1	0.000004	0.00209	6.17170	0.01289
4	Gentianaceae	*Anthocleista Schweinfurthii*	6	0.00016	0.01253	4.37994	0.05486
5	Gentianaceae	*Anthocleista vogelli*	16	0.00112	0.03340	3.39911	0.11354
6	Meliaceae	*Azardirachta indica*	125	0.06810	0.26096	1.34339	0.35057
7	Arecaceae	*Borrassus aethiopum*	37	0.00597	0.07724	2.56078	0.19781
8	Polygalaceae	*Carpolobia lutea*	1	0.000004	0.00209	6.17170	0.01289
9	Malvaceae	*Ceiba pentandra*	2	0.000017	0.00418	5.47855	0.02288
10	Fabaceae	*Daniellia oliveri*	46	0.00922	0.09603	2.34306	0.22501
11	Leguminosae	*Dialium guineense*	1	0.000004	0.00209	6.17170	0.01289
12	Myrtaceae	*Eucalyptus camaldulensis*	32	0.00446	0.06681	2.70597	0.18077
13	Myrtaceae	*Eucalyptus globulus*	20	0.00174	0.04175	3.17597	0.13261
14	Moraceae	*Ficus capensis*	1	0.000004	0.002088	6.171701	0.012885
15	Lamiaceae	*Gmelina arborea*	25	0.00272	0.052192	2.952825	0.154114
16	Apocynaceae	*Holarrhena floribunda*	1	0.000004	0.002088	6.171701	0.012885
17	Meliaceae	*Melicia excelsa*	11	0.00053	0.022965	3.773805	0.086664
18	Rubiaceae	*Morinda lucida*	4	0.00007	0.008351	4.785406	0.039962
19	Bignoniaceae	*Newbouldia laevis*	39	0.00663	0.08142	2.508139	0.204212
20	Fabaceae	*Pentaclethra macrophylla*	1	0.000004	0.002088	6.171701	0.012885
21	Pinaceae	*Pinus caribaea*	32	0.00446	0.066806	2.705965	0.180774
22	Lamiaceae	*Tectona grandis*	5	0.00011	0.010438	4.562263	0.047623
23	Fabaceae	*Tetrapleura tetraptera*	5	0.00011	0.010438	4.562263	0.047623
24	Moraceae	*Treculia africana*	1	0.000004	0.002088	6.171701	0.012885
25	Verbenaceae	*Vitex doniana*	48	0.01004	0.100209	2.3005	0.23053
			479	0.88346			2.50817

Table 3: Diversity indices

Diversity indices	Values
Number of species	25
Number of family	17
Shannon-Weiner	2.51
Simpson dominance index (C)	0.88

DISCUSSION

The tree species (25) distributed into 17 families in the study area implies that the vegetation is rich but lower than what was reported by Olajuyigbe *et al.* (2013) for tree species diversity in the Department of Forest Resources Management, University of Ibadan, Nigeria where a total of 76 trees of 27 species distributed in 15 families were recorded. The result of this study is higher than that of Kacholi (2019) who reported 24 species belonging to 11 families in his study on the assessment of tree species richness, diversity, population structure and regeneration in Nongeni forest reserve, Morogoro, Tanzania. Compositions of plants species across ecological zones varied greatly. The variances in the result of this study may be due to the degradations by anthropogenic activities as well as climate, topographical localities, ecological zones of the study area. Bello *et al.* (2013) affirmed that unpredictability in terms of anthropogenic activities; ecological zones, climate and weather are major driving factors determining the abundance and distribution of plant species.

The family Fabaceae has the highest diversity of four (4) species in this study. Other important families dominating the study area include the Apocynaceae, Lamiaceae, Moraceae and Myrtaceae with same number of species (2) identified. This is similar to the findings of Omorogbe (2004) and Kacholi (2019) who reported 14 and 9 species from Fabaceae family having the highest species diversity in Sakponba Forest Reserve, Edo State, Nigeria and Nongeni forest reserve, Morogoro, Tanzania respectively. Omorogbe (2004) also reported that Fabaceae was distantly followed by Meliaceae with seven species; Annonaceae and Sterculiaceae with six species each, Moraceae and Apocynaceae had five while Euphorbiaceae had four.

Azardirata indica, *Vitex doniana*, *Tectona grandis*, *Eucalyptus camaldulensis*, *Ficus capensis* and *Daniella oliveri* had the high percentage of distributions. The trees cover a wide range of tangible and intangible uses which include medicinal, timber, food, fodder, fuel, aesthetics and soil protection, carbon sequestration and shade. This high species diversity is a representation of the tree stock found on the University campus. Some of these species are threatened and endangered, thus, raises an alarm on the need to begin deliberate conservation and regeneration for these trees. Some of these species listed in the IUCN threatened species red list include: *Khaya grandifoliola* C. DC., *K. senegalensis* (Desr.) A. Juss., *Milicia excelsa* (Welw) C. and *Delonix regia* (Hook) Raf. (IUCN, 2012).

CONCLUSION AND RECOMMENDATION

This study revealed that there is diversity of open grown tree species found in Nnamdi Azikiwe University, Awka. The disturbances caused by the demand for timber and non-timber products by both the University administration and community, coupled with the challenges of species adaptation to climate change pose a great threat to the continuous survival and sustenance of these tree species. Therefore, there is an urgent need for conservative measures and policy intervention in the management of trees on the campus as well as prompt conservation of the genetic resources found on the campus.

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Evaluation of Flora Composition and Utilization in Ikwe Game Reserve, Igbor, Gwer L.G.A., Benue State, Nigeria

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ABSTRACT

There are different types of protected areas, and the purpose for their establishment is very broad. Persistent ecosystem monitoring is crucial to the fulfillments of every conservation objectives; however, at present no comprehensive record of flora composition at the study area. This study was carried out to determine the species composition, percentage distribution, and structure and utilization level at the study area. The point centered quarter (PCQ) method and the step point line technique (SPLT) were used as sampling points. All encountered trees species within the PCQ were identified and recorded. The result revealed that there are 32 woody plant species from 20 families. The dominant family was Caesalpinodae. In woodland the common species was Prosopix africana (12.14 %) while in the riparian vegetation Syzygium guineense (24.12 %) was the dominant woody plant species. The hilly vegetation recorded Berlinia auriculata (45 31 %) as the dominant species. The riparian vegetation had the highest density per hectare (617 trees/ha) followed by the hilly vegetation (13 trees/ha) and the woodland (2 trees/ha). The species diversity index showed that the woodland is slightly above the riparian by 0.2, while the hilly has the lowest diversity index (0.3). Only two plants were utilized by animals; Oryza sativa and Manihot esculenta. The difference in species composition is attributed to human activities. It is therefore strongly recommended that Silvicultural management practices should be intensified at the study area.

INTRODUCTION

There are different types of protected areas, and the purpose for their establishment is very broad. It could be to maintain the life supporting diversity of ecosystems, protect species needed for human needs, or safe-guarding the world's areas of natural beauty (Krishna, 1997). These human needs ranges from educational, research, food, raw materials, income generation and, or ecological tourism.

According to Marguba (2002) there are about 30,000 protected areas around the world, and it is touted as one of the greatest achievements of the 20th century and a great inheritance for 21th century. Over the last two decades, there has been a relatively rapid growth in game reserves and, or protected areas obviously due to the perceived importance attached to them, Dudly N. (Editor) (2018). However, the total number of protected area records in the March 2023 released of World Database Protected Areas (WDPA) is 285534 comprising 273,268 polygons and 12266 points and covering 244 countries and territories.

Agbelusi (2000), in the study on conservation of biodiversity asserted that, Nigeria like many African countries is faced with the problems of environmental destruction fueled by increase in population growth, political instability and increasing poverty. At each point of these cycles species are lost and biodiversity is obtainable only in the National parks, game reserves, forest reserves, wildlife sanctuaries etc. In view of this, parks and protected areas will continue to be necessary for the protection of species whose habitats are not compatible with man (Eltringham, 1984). Moreover, a game reserve is an area of land set aside for the preservation of wildlife. It is pertinent to note that, wildlife cannot be preserved in isolation from flora resources. This is because the flora resources constitute a source of food, shelter, habitat and so on; to the wildlife. Although, management plays an important role in protecting habitat for flora and fauna, it is essential that established areas be manipulated to guarantee the stability or survival of certain species of plants and animals (FAO, 1988).

It is important to regularly assess the health of the vegetation and when necessary manipulate it to suite wildlife management needs (Ayodele *et. al.,* 1999). Ikwe Game Reserve is a product of an attempt by the Benue State Government to conserve biological diversity in-situ. The need to plan natural resources management on the basis of accurate inventory and taking protective measures to ensure that the resources do not become exhausted are the concepts of modern conservation. Therefore the main objective of this study is to determine the species composition and distribution of woody plants structures and their utilization at the study area.

MATERIALS AND METHODS

Study area

Ikwe Game Reserve is situated in Igbor, Gwer Local Government Area of Benue State, Nigeria. It is about thirty kilometers (30 km) south of Makurdi, the State Capital. The towns and villages bordering the reserve are Otukpo, Aliade, Igbor, Kwagh Akume, Koodar and Makurdi. The reserve is located at latitude 7°15-7°17'N and 8°20-8°22'E geographic coordinate. It surrounds Ikwe Hills and covers a total area of about 40 km². Ikwe Game Reserve could have been very accessible, since it is surrounded by many towns and villages. A 9 km fence is erected using chain link fence wire supported with concrete poles.

The major drainage channel comprises of tributaries of River Benue, which includes Aundu and Bai streams which drains the upper part of the reserve. Akume Arite, and Tyumando streams drains the central part of the reserve, while Fete drains the lower part. In the dry season these tributaries breaks into brooks, pools, streams and water holes which provide water for wildlife population in the reserve Jimoh *et al.,* (2010).

The climate is similar to that of Guinea Savanna, the duration of rainfall ranges from 125-200 days (6-7 months), Annual rainfall of the zone ranges from 1,140mm-1,520mm and evapotranspiration is between 0.40-0.70. The trees and grasses are characteristically tall. Sampling Method

Systematic and stratified random sampling was adopted based on structural appraisal and dominant features of the environment; Woodland, Riparian and Hilly. Three line transect were laid each for the vegetation types systematically, making a total of nine transects. The point centered quarter (PCQ) method by Pollard (1971) and Mitchell (2010) and the step point line technique (SPLT) by Ridney (1963) were used as sampling points at 0.25/ha. A total of 10 PCQ were laid in each of the three vegetation zone. All encountered trees species within the PCQ were identified and recorded by their local and scientific names with the help of a taxonomist, trees species that could not be identified in the field, their specimen were collected and taken to the Herbarium of Federal University of Agriculture Makurdi, for identification.

Data Analysis

Woody plant density, percentage distribution of woody plant, and species diversity index were calculated from the formulae given by Cottam and Curtis (1956), Ayodele *et. al.,* (1999) and Simpson (1949). Species Diversity Index (SI) was calculated using the formulae:

$$SI = \frac{N(N-1)}{\sum_{i=1}^{q} n(n-1} \qquad (1)$$

Where; SI = Diversity Index, N = Total number of individual trees q= No of different species of trees, n = number of individuals of ith species of trees.

RESULTS

Species composition and distribution percentage of woody plants in the three vegetation types

The results of Species composition and percentage (%) distribution of woody plants in vegetation types as presented in Table 1 depicted that there was paucity of species per vegetation type where an individual species occurred in all the vegetation types was examined. The dominant woody plant species that was recorded in the hilly vegetation was *Berlinia auriculata* (45.31 %), followed by *Lophira lanceolata* and *Pericopsis laxiflora* (10.94) while the lowest was *Lannea schimperi* (3.13) %. In the riparian vegetation, the dominant woody plant species was *Syzygium guineense* (24.12%) followed by *Berlinia auriculata* (14.47%), *Diospyros mespiliformis* (9.21%), *Acacia polyacantha, Khaya senegalensis* and *Vitex doniana* (7.02%) while *Phyllanthus muellerianus*had the lowest percentage (1.32) %. In the woodland vegetation, *Prosopis africana* (12.14%) is the dominant woody plant species, followed by *Lonchocarpus laxiflorus* (8.57%), *Ficus sycomonus, Vitex doniana* (7.86), *Detarium senegalensis* and *Lannea schimperi* (7.14%). The least species in woodland was *Stereopermum kunthianum* (1.44%).

Table 1: Species composition and percentage (%) distribution of woody plants in vegetation types

S/n	Species	Hilly (%)	Riparian	Wood land (%)
1	*Acacia polyacantha*	-	7.20	
2	*Annona senegalensis*	-	-	3.57
3	*Berlinia auriculata*	45.31	14.47	5.71
4	*Bridelia ferruginea*	-	3.07	2.86
5	*Cussonia arborea*	-	-	2.86
6	*Daniellia oliveri*	8.59	3.07	-
7	*Detarium senegalenssi*	5.47	-	7.14
8	*Diospyros mespiliformis*	-	9.21	-
9	*Diospyros senegalensis*	-	2.63	-
10	*Ficus congensis*	-	2.63	-
11	*Ficus sycomorus*	-	-	7.86
12	*Garcinia smeathmannii*	-	3.07	-
13	*Khaya senegalensis*	-	7.02	-
14	*Lannea schimper*	3.13	-	7.14
15	*Lonchocarpus laxiflorus*	-	-	8.57
16	*Lophira lanceolata*	10.94	-	4.30
17	*Mangifera indica*	-	-	3.5
18	*Maytenus senegalensis*	-	2.19	-
19	*Parinari curatellifolia*	-	-	5.00
20	*Parkia bigloss*	-	-	2.86
21	*Pericopsis laxiflora*	10.94	-	3.57
22	*Phyllanthus muelleriansus*	-	1.32	-
23	*Piliostigma thonningil*	-	2.19	-
24	*Prosopis africana*	3.91	-	12.14
25	*Pterocarpus erinaceus*	5.47	-	-
26	*Quassia undulate*	-	-	2.86
27	*Sarcocephalus latifolius*	-	3.07	4.28
28	*Stereopermum*	-	-	1.3
29	*Syzygium guineense*	-	24.12	4.3
30	*Terminalia macroptera*	6.24	2.02	2.32
31	*Uapaca togoensis*	-	5.70	-
32	*Vitex doniana*	-	7.02	7.86
	Total	100	100	100

Family composition, the frequency occurrence of species and their relative abundance

Table 2 showed the results of the families and their number of species compositions. The two predominant families were *Caesalpiniodae* and *Papilionoidae*, comprising of four (4) species each, and percentage relative abundance of stems per family of 28.03% and 8.87% respectively.

Woody (tree) plant density/hectares and species diversity of the vegetation types in the study area

Table 3 revealed that tree density/ha and species diversity of the vegetation types, the highest mean tree density of 617 trees/ha occurred in the Riparian vegetation. The least mean tree density/ha of 2 trees/ha occurred in the woodland. The results on species diversity in the same Table revealed that the Woodland had the highest mean species diversity of 9.79. The riparian vegetation had 9.59 as its species diversity index while in the Hilly vegetation 0.3 was obtained for the hilly vegetation

Among all the plants species in the vegetation zone, only two were identified to be utilized by wild animals out of the 48 plants species recorded in the game reserve. These two plants were *Oryza sativa* and *Manihot esculenta*. These plants were found to be slightly utilized. In the case of *Oryza sativa*, the part utilized was the leaves, while for *Manihot esculenta*, it was the stem.

Table 2: Family composition, number of species per family and relative abundance of each family

S/N	Families	Species per Family	% Relative Abundance
1	Anacardiaceae	2	3.83
2	Annonaceae	1	1.01
3	Araliaceae	1	0.81
4	Bignoniaceae	1	0.40
5	Caesalpimiodeae	4	28.03
6	Celastracea	1	1.01
7	Chrysobalanaceae	1	1.41
8	Combretaceae	1	3.23
9	Ebanaceae	1	4.23
10	Euphorbiaceae	3	5.44
11	Guttiferae	1	1.41
12	Melaceae	1	3.23
13	Melaceae	3	8.48
14	Moraceae	2	3.43
15	Myrtaceae	1	12.30
16	Ochnaceae	1	4.03
17	Papilionoidae	4	8.87
18	Rubiaceae	1	2.62
19	Simaroubaceae	1	0.81
20	Verbanaceae	1	5.44

Table 3-: Woody (tree) plant density/hectares and species diversity of the vegetation types of Ikwe Game Reserve

Riparian Vegetation		Woodland Vegetation		Hilly Vegetation	
Density/ha	Species Diversity	Diversity/ha	Density species	Density/ha	Species diversity
644	3.69	0.93	10.07	14	0.20
729	13.45	2.07	8.67	12	0.30
47	11.62	1.94	10.64	14	0.30
Mean 617	9.59	2.00	9.79	13	0.30

DISCUSSIONS

The result of the evaluation of vegetation types of Ikwe Game Reserve showed that the plants species compositions in the reserve were consistent with those in the Guinea Savanna of West Africa confirming the findings of Keay (1959) and Adeniji *et al.* (2022). The predominant representation of most of the families by one or two species is a feature that is peculiar to the savanna vegetation. In this study *Prosopis africana* is the predominant woody plant species in the woodland. This is probably due to the protection it enjoys based on its economic importance to the rural economy. It serves as a source of local condiment to the local people. The absence of common woodland vegetation species such as *Khaya senegalensis, Vitallaria paradoxa* and *Vitex doniana* in relatively high abundance could be due to the fact that the woodland vegetation has been grossly degraded by the rural people for agricultural activities and the fact that they are exploited for timber and char coal. These species are the commonest in the Guinea savanna zone of Nigeria as documented by Afolayan (1977), Ayeni *et al*. (1982), Tyowua (2002) and Adeniji *et al.* (2022)

The riparian recorded species such as *Syzygium guineense* (24.12%), *Berlinia auriculata* (14.47%) and *Diospyros mespiliformis* (9.21%) as predominant species respectively. Geerling (1973) asserted that the riparian vegetation is peculiar vegetation consisting of species more characterized of forest zone such as *Syzygium guineense*. The hilly vegetation recorded species like *Berlinia auriculata* (45.31%) followed by *Lophira lanceolata* and *Pericopsis laxiflora* (10.94%) as the predominant species respectively.

This study revealed that the number of trees/ha in the riparian vegetation was more than that of the hilly and woodland vegetations, despite the fact that area covered by the woodland was more than the riparian. This could be explained by the fact that the woodland vegetation has been grossly intruded by the surrounding communities. Thus human activities such as farming, firewood collection for fuel and logging could be attributed to the immense loss in the flora resources within the woodland vegetation, hence, destruction of wildlife habitat being eminent. To further buttress the aforementioned fact, Table 2 showed that there are more trees/ha in the hilly vegetation than there are in the woodland.

Woodland vegetation has the highest diversity index compared to riparian and hilly Vegetation. Diversity index therefore, is a number that gives the resource manager an idea of the variation of species varieties between stable and unstable environment over successional times. It also reflects the health of a given environment. Communities that have been stressed usually have lower diversity index than the unstressed communities. However, the results of the number of trees/ha depicts the true state of the three types of vegetation. The lowest diversity index value for the hilly vegetation could be due to the nature of the terrain which most likely restricts woody plants growth.

The conversion of the woodland into grassland or bare-ground is attributed to human population growth and antecedent increase in demand for land by humans for activities such as farming, firewood collection, char coal production, logging and so on. The woodland is tempered with annually for these purposes. These concurs with the findings of Hopkins (1965) as cited by Afolayan and Agbelusi (1995) and Tyowua (2002), who reported that man's interference with the woodland vegetation through clearing of vegetation for farming, firewood for fuel consumption and indiscriminate use of fire. On utilization by animals, the result showed a very low utilization status, thus implying that there is low population of wild animals in the game reserve and also considering the period of the year that the study was carried out.

CONCLUSION

The differences in species composition in the study area is attributed to human activities such as logging, farming and felling of trees for fuel-wood consumption in the woodland vegetation. The species composition of Ikwe game reserve conforms to other conservation areas within the Guinea savanna region of West Africa. The most ubiquitous woody species in the study area are *Berlinia auriculata* and *Terminalia macroptera*. The study area depicted low utilization of plants by animals at the moment hence there is need for further evaluation in terms of the fauna resources in the appropriate time and season, so that the park can be put into use properly.

RECOMMENDATION

Ikwe Game Reserve is an asset that the Benue State Government can explore for its renewable potentials and richness in terms of flora and fauna resources, scenery and other natural features. It has the potentials of becoming a major source of revamping the local economy of the rural people and the state at large. Based on these, we wish to make the following recommendations;

Successive research aimed at providing quantitative and qualitative data on the fauna resources endemic in the area. These data will serve as baseline information for further researches in the future.

i. Silvicultural management practices should be encouraged to be able to revamp the various vegetation types to enhance speedy recovery from the disturbances that it has suffered in the past. For instance, in the riparian vegetation, management practices that will encourage the growth of seedlings and saplings should be employed so that there will be even distributions of the various diameter classes of trees in the future.

ii. There is an urgent need for strong advocacy, community sensitization and continuous engagement to sensitize locals on the need for conservation and sustainable use of resources in the reserve.

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Response of Storage Fungi of Onion (*Allium cepa*) to selected Botanicals

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K E Y W O R D S

Botanicals,
Onion bulbs,
Post-harvest fungi,
Rot-causing fungi,
Pre and post infection.

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A B S T R A C T

Onion (Allium cepa) produced bulbs are mostly lost after harvesting due to rots caused by fungi. Extracts of many plants are effective for control of fungal pathogens. So far, little information is available on the use of several plant extracts in controlling rot of onion bulbs caused by plant pathogens during storage. Therefore, this study aimed to isolate and identify rot-causing fungi of onion sold in Umuahia and their response to selected botanicals. Infected onion (White and red) n= 12, were sourced from Orie-Ugba and Ubani markets for isolation and identification using standard techniques. Also, response of Rhizopus sp, Fusarium sp and Aspergillus niger to aqueous extracts of clove and African nutmeg seeds were evaluated in-vitro and in-vivo (before and after treatment). Experiments were laid out in CRD in triplicates. Clove (Syzgium aromaticum) and African nutmeg (Monodora myristica) extracts respectively reduced Aspergillus niger (71.55, 42.96%) Fusarium sp (63.82,58.28%), and Rhizopus sp (67.79,26.06%) in-vitro. Clove applied before and after fungi inoculation respectively reduced growth of Aspergillus niger (69.64,60.71%), Rhizopus sp, (88.89,84.44%) and Fusarium sp (70.00, 58.89%) in-vivo. Growths of Aspergillus niger (69.64,69.64%), Rhizopus sp, (50.00,53.33%) and Fusarium sp (82.22,58.89%) were reduced by African nutmeg before and after treatment respectively. Extracts showed promising prospect for control of Fusarium sp, Aspergillus niger and Rhizopus sp growth in both trials and could be explored for management of post-harvest onion rots at pre and post stages of fungal infection.

INTRODUCTION

Onion (*Allium cepa*) is a round vegetable that grows underground. The bulb can be white, yellow and red; the red is the most popular one in the country and it is of great commercial value for farmers that cultivate it (Fritch *et al.*,2002). The main cause for the reduction in onion yield is the various fungal infections that infect it especially during long term storage. Despite the advances in production techniques the post-harvest loss during storage is still a major problem. Storage diseases of onions are bacterial rots, black mould (*Aspergillus niger*), Blue- green mould, Fusarium rot, neck rot, brown rot and soft rot. These storage diseases manifest rapidly depending on the condition on how the onion bulbs were planted. Different types of onion bulbs are infected in storage places. Hence the need to isolate and identity these diseases causing pathogens and proffer some management practices to reduce rots and spoilage during storage (Sang *et al.,* 2018). Natural plant products have often been considered as important and alternative sources of agricultural chemicals and most have been used in the control of insect pest (Enyiukwu *et.al.,* 2016) and as bird repellent (Nisar *et.al.*, 2020). So far, little information is available on the use of several plant extracts in controlling rot of onion bulb caused by plant pathogens during storage. Therefore, the objectives of this study are: to isolate and identify fungi causing rot of onion bulbs in Umuahia, to determine the effect of identified fungal organisms on onion and the effect of selected botanicals on fungi isolated from rotted onion bulbs.

MATERIALS AND METHODS

Experimental site and Source of Onion bulbs: Multiple onion (white and red) samples were purchased from different points in Orie Ugba (5˚32N 7˚30E) and Ubani (5˚35N 7˚30E) both in Umuahia, Abia State. Each type of onion was purchased from three traders at different locations within the same market; these served as the replicates which were used for investigation in the laboratory of Department of Plant Health Management, Michael Okpara University of Agriculture, Umudike.

Isolation of Fungi from Infected onion bulbs and Identification of Isolated Fungi: Samples of infected onion bulb were surface sterilized with 70% ethanol and then rinsed in three changes of sterile distilled water to remove surface contaminants and dried with sterile paper towel. Then isolation was carried out according to the method described by Opara and Obani (2009). Using inoculation needle, the sterilized infected samples of onion bulb were cut with sterilized surgical blade to small pieces which were inoculated on solidified PDA in the Petri-dishes and incubated at room temperature (28°C). Potato Dextrose Agar (PDA) powder 39g was prepared according to manufacturer's guide and 2 drops of lactic acid was added to the PDA prevent bacterial growth. Inoculated plates were observed 3-5 days for fungal growth and fungal colonies that grew from the inoculated plates were sub-cultured to obtain pure cultures of different isolates.

Pathogenicity test: Pathogenicity test was carried out according to Amadioha and Uchendu (2003); healthy onion bulbs were surfaced sterilized with 70% ethanol for 30 seconds and then rinsed in three changes of sterile water, dried and the inoculated with a 7-day-old fungal culture of each isolate. The point of inoculation was smeared with Vaseline to seal the inoculated portion on the onion bulb in other to prevent contamination. The control was inoculated with a disc portion of solidified potato dextrose agar medium alone and all inoculated bulb were kept in a micro humid chamber, incubated for 7 days and infected bulb that showed sign of rot were re-isolated as described above according to Koch's principle. The morphology and culture characteristics observed were compared with fungal structures in manual Snowdown (2015).

Source and Preparation of Plant Extracts: Dried seeds of *Syzgium aromaticum* (Clove) and *Monodora myristica* (Ehuru/African Nutmeg) obtained from Orie-Ugba market were washed with running tap water and then rinsed with sterile distilled water and their extracts prepared according the methods described by Amadioha (2000).

Effect of Botanicals on radial growth of isolated fungal species *in vitro*

Application of the treatments was done according to the methods of Amadioha (2000). The water extract of each plant materials, (0.2m1) each were separately introduced into petri-plates containing the solidified media (poisoned food method). The extracts were uniformly spread to form a thin film on the solidified PDA. A disc of 6mm diameter of the pure culture of each test fungus was placed at the point of intersection of the two perpendicular lines drawn at the bottom of the extract-PDA medium plate. Control plates were prepared with 0.2m1 of sterile distilled water alone without plant materials. The plates were incubated at room temperature (28°C) until the mycelium or hyphae growth of fungus in the control experiment reaches the edge of the plate. Three replicates were set up for each treatment, experiment was replicated 3 times. The radial mycelia growths were measured in each case using metric rule for both treated plates and control. Percentage growth inhibition was calculated using the formular below;

$$\text{Percentage growth inhibition (\%)} = \frac{DC\text{-}DT}{DC} \times \frac{100}{1}$$

Where; DC= Average diameter of fungal colony in control experiment plates and DT= Average diameter of fungal colony in treated plates

Effect of Treatments on Rot Development in Onion Bulb: The test of the effect of the treatment on fungal deterioration of onion (in-vivo experiment) was carried out following the method of Amadioha *et al.,* (2012). The extracts were prepared as described above. Inocula suspensions of *A. niger, Fusarium* sp and *Rhizopus* sp were prepared from fresh, mature (5-day-old) fungi cultures. Healthy onions were washed in three changes of sterile distilled water and dried with sterile paper towel. Onion bulbs were bored with 5 mm cork borer, then 5 mm disk of each test fungi from culture plate was placed in the 5mm whole made with the cork borer of allowed to stand for 30 minutes before treatment with botanical extracts and then incubated on sterile filter paper blotter. For samples treated before inoculation, onion bulbs were treated with crude botanical extracts and wrapped with sterile paper towel and allowed to stand for 30 mins before inoculated with test fungi and placed on sterile wet filter paper blotter. Both samples inoculated before and after treatment and control (triplicates each) replicates were incubated at room temperature for 14 days and percentage fungi colonization was recorded after incubation.

Disease severity was determined using a scale ranging from 0 to 5 as follows: 0-No infection/rot, 1 to 20% - Slight rot, 21 to 40% - Moderate rot, 41 to 60% -Severe rot, 61 80% -Highly rotted, 81 to 100% - complete rot

Statistical Analysis: Data collected from all the experiments were analyzed using Statistical Package and Service solutions (SPSS) version 23; means were compared and separated using least significant difference (LSD) and at 5% probability level.

RESULTS

Incidence of fungal species in onion bulbs: Figure 1 showed the percentage incidence of the seven (7) fungal species isolated from both red and white onion sourced from Orie Ugba and Ubani. The chart represents that *Aspergillus niger* had the highest occurrence for both red and white onion bulbs sourced from Orie ugba and Ubani markets except for red onion bulbs collected from Ubani. *Rhizopus* sp had the highest incidence level in red onion bulbs sourced from Ubani and also followed those collected from Orie ugba market. The least incidence level of the fungal pathogens was observed in all onion bulbs with *Fusarium* sp having the lowest incidence, followed by

Aspergillus flavus and then *Penicillium* sp. Results shows that *Rhizopus* sp should be placed as a priority and considered during storage of both red and white onion bulbs.

Pathogenicity Test: Table 1 shows the different fungi isolated from red and white onion bulbs, their symptoms and their pathogenicity test (%). Two *Fusarium* species (*F. solani* and *F. oxysporium*), *Rhizopus stolonifer, Botryodiplodia theobromae, Penicillium* sp and *Aspergillus* species (*A. niger A. flavus* and *A. tamarii*) were isolated from onion bulbs.

The pathogenicity test showed that the fungi were pathogenic to onion bulbs at varying percentages However, *A*. niger had high pathogenicity percentage in both white (60%), and red (70%) onion, Rhizopus sp (40%) and 20% while *Fusarium solani* had rot development of 40% and 40% in both white and red onion bulb respectively.

Effect of crude extracts of clove and ehuru on mycelial growth of fungi in-vitro: Table 4.2 and plates 4.2 - 4.3 show the effects of the crude extracts of Clove (*Syzgium aromaticum*) and Ehuru (*Monodora myristica*) percentage growth inhibition of the mycelia growth of the test fungi in culture. The botanical extracts had significant effect on the mycelia growth of the test fungi.

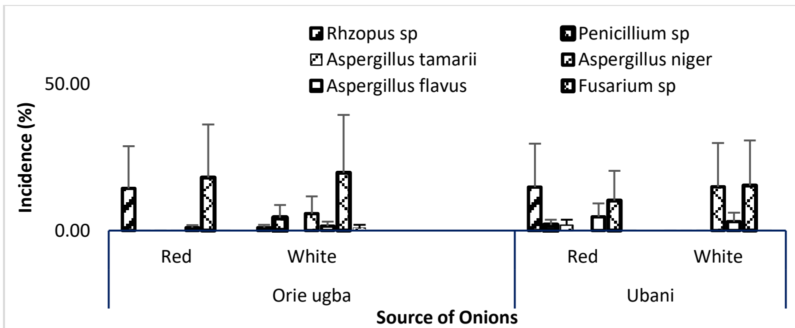

Figure 1: Percentage incidence of fungal species isolated from onion bulbs.

For *A. niger*, both Ehuru and clove had 100% growth reduction at 6 days. However, growth reduction of 52.52 to 70.84% was recorded from day 2 to day 6 for Ehuru, while 24.24 to 67.16% was recorded for clove. The difference in mycelia growth of the treated from the control was significant at ($p \leq 0.05$).

Table 1: The pathogenicity of fungi isolated from onion bulbs.

Rot Colour	Fungi isolated	Pathogenicity (%) White onion	Severity index	Red Onion	Severity index
Light brown	*Botryodiplodia theobromea*	30	2	20	1
Light brown	*Rhizopus* sp	40	2	20	1
Dark brown	*Pencillium* sp	40	2	20	1
	Aspergillus tamarii	30	2	20	1
Dark brown	*Aspergillus niger*	60	3	70	4
Light brown	*Aspergillus flavus*	20	1	20	1
Brown	*Fusarium solani*	40	2	40	2
Brown	*Fusarium* oxysporium	30	1	30	2
	Control	0	0	0	0

A similar trend was observed for *Fusarium* sp mycelial growth reduction, day 1 had 100% mycelia growth reduction but reduced significantly from day 2 to day 6. For *Rhizopus* sp, Clove had 100% growth reduction in day 1-2, within a sharp decrease to 21-24% in day 3and 4, although significantly different from control (0.00%). For Ehuru, mycelia growth reduction ranged from 21.69-31.67% and were significantly different ($p \leq 0.05$) from the control.

Effect of crude extracts of clove and Ehuru **on reduction of rot development of fungi in-vivo**

In vivo effect of the crude plant extracts on the growth and sporulation of *A. niger, Rhizopus* sp, *Fusarium* sp before and after inoculation**.**

Table 2: Percentage (%) reduction of mycelia growth of fungi by crude extracts of botanicals *in-vitro*

		Growth Reduction (%) Days after treatment						
Botanical extract	**Fungi**	**1**	**2**	**3**	**4**	**5**	**6**	**Mean**
Ehuru		100.00	69.34	70.38	66.20	52.52	70.84	70.69
Clove		100.00	67.16	63.91	48.52	45.82	24.24	65.08
Control	*Aspergillus niger*	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LSD(p=0.05)		0.54	11.72	16.98	5.09	2.68	1.23	
								70.01
Ehuru		100.00	79.35	80.00	35.96	54.76	56.67	
Clove		100.00	60.70	41.29	16.08	14.38	25.29	46.49
Control	*Fusarium* sp	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LSD(p=0.05)		0.77	8.86	18.13	19.41	13.09	5.06	
Ehuru		26.26	31.67	21.69	24.63			26.06
Clove	*Rhizopus* sp	100.00	100.00	28.44	26.85			63.82
Control		0.00	0.00	0.00	0.00			0.00
LSD(p=0.05)		18.85	5.40	3.62	5.20			

The effect of the plant extracts applied before and after inoculation of fungal isolates *in vivo* is presented in Table 3. The extracts of *Syzgium aromaticum* (Clove) and *Monodora myristica* (Ehuru/African Nutmeg) had a significant effect on the isolated fungi rot before and after inoculation when compared with the control. The application of Ehuru extract before treatment inhibited the *A. niger* by 69.64 and 60.71% after treatment compared to control (0.00%). However, application of Clove before and after treatment respectively, was recorded for clove while Ehuru had 50.00% and 53.33% before and after treatment respectively; with mean difference significantly different from the control (0.00%). before and after treatment respectively, was recorded for clove while Ehuru had 50.00% and 53.33% before and after treatment respectively; with mean difference significantly different from the control (0.00%). Extracts before and after inoculation of fungal pathogens inhibited the growth of *A. niger* by 69.64%compared to the control. Reduction of mycelia growth of *Rhizopus* by 88.89% and 64.44%.

For *Fusarium* sp, Ehuru reduced the fungal growth by 70.0% and 58.89% before and after treatment respectively. Clove significantly inhibited the growth of *Fusarium* sp by 82.22% before treatment and 58.89% after treatment and differed significantly from the control.

Results therefore, showed that clove seed extracts were more effective in inhibiting the growth of test fungi (64.44) when applied before inoculation of the fungal isolates than those of *Monodora myristica*. Results also showed that clove extracts were more effective in inhibiting the growth of *Rhizopus* sp and *Fusarium* sp than that of *Aspergillus niger*. Application of the plant extracts before and after inoculation of the pathogens reduced disease incidence significantly ($p \leq 0.05$) when compared with control experiment.

Table 3: Percentage (%) reduction of rot development of fungi by crude extracts of botanicals *in-vivo*

		Growth reduction (%)	
Botanical extract	**Fungi**	**Before**	**After**
Ehuru	*Aspergillus niger*	69.64	60.71
Clove		69.64	69.64
Control		0.00	0.00
LSD(p=0.05)		8.58	13.57
Ehuru	*Rhizopus* sp	50.00	53.33
Clove		88.89	64.44
Control		0.00	0.00
LSD(p=0.05)		21.00	23.66
Ehuru		70.00	58.89
Clove		82.22	58.89
Control	*Fusarium* sp	0.00	0.00
LSD(p=0.05)		8.11	7.91

DISCUSSION

The efficacy of two plant extracts were tested *in vitro* and *in vivo* against the growth of three pathogenic fungi that were isolated from stored onion bulbs. The prevalently fungal pathogens isolated were identified as *Aspergillus niger*, *Fusarium* sp and *Rhizopus* sp. The results of this study revealed that the fungi were majorly responsible for the post-harvest rot of red and white onion bulbs in Umuahia as evidenced by the pathogenicity tests. The pathogens (*Aspergillus niger*, *fusarium* sp and *Rhizopus* sp) were also reported by Shehu and Muhamed (2011) to cause storage rot of onion bulbs.

Also, Adebayo and Diyaulo (2003) reported (*Aspergillus niger* and *Rhizopus* sp) as pathogens of post-harvest rot of onion, which is in agreement with the finding of this study. This study reported that, application of botanicals before and after fungi inoculation showed antifungal activity and can be used in control of *A. flavus*, *Fusarium* sp and *Rhizopus* sp causing rot in of onion bulb. Some of the plant extracts of *Dioscorea dumetorum*, *Azadirachta indica*, etc. have been studied in Nigeria with a view to manage rot of onion bulb. Okey *et al.,* (2015) reported that ethanolic extracts of *D. dumetorum* was found to be more effective in inhibiting the growth of *Rhizopus stolonipher* and *Aspergilus niger* than *P. guajava* extracts. Enyiukwu *et.al.,* (2016) also reported that, extracts from *Azadirachta indica* and *Dennettia tripetala* should be applied as prophylactics and or before disease initiation for management of soil and thrash-borne fungal diseases of onion crop in integrated diseases management programmes in sun-Saharan Africa (SSA) for improved onion production. *Cydonia oblonga, Datura stramonium, Eucalyptus globules, Foeniculum Salix mucronate* and many other plants have been found to the effective against fungal pathogens in harvested bulbs and it has been used to control Stemphylium blight diseases of onion caused by *S. vesicarium* and *Botrytis squamosa* (Sobhy *et al.,* 2013).

The differences in the fungi-toxic potentials between these plant extracts studied may be attributed to the susceptibility of each of the fungal pathogens to the different constituents of the extracts. This agreed with the results of some workers like Amienyo and Ataga (2007), who reported that plants are rich source of bioactive compounds such as tannins, terpenoids, saponins, alkaloids, flavonoids and other compounds as such have antifungal properties. Chowdhury *et al.,* (2016) reported that the plant extracts of *Allium sativum*, *Azadirachta indica*, *Citrus limon* and *Mangifera indica* showed complete growth inhibition of *Aspergillus niger* and *Fusarium* sp at 6 days and when applied before and after pathogen inoculation. This in synergy with the same test fungus used in this study. The variation might be due to selection of different plant extracts. Islam and Shamsi (2016) reported association of seven species of fungi namely *Aspergillus flavus, A. fumigatus, A niger, Fusarium* sp, *Penicllium* sp, *Rhizopus stolonipher* and *Trichoderma* sp. They also reported that bulb extracts of *Allium sativum, Azadirachta indica* and the chemical sodium showed 100% growth inhibition of the isolated fungi.

Srinivasan and Shanmugam (2006), and several others numerous authors have also reported that, the presence of these compounds in plant could be responsible for the control of fungal pathogens of plant. Nwaiwu and Imo (2019) screened *Monodora myristica* for the fungitoxicity of their essential oils against mycelia growth of three fungi species; *Aspergillus niger*, *Rhizopus* sp and *Aspergillus fumigatus*. The ethanolic extract of *Monodora myristica* seed possess broad spectrum antifungal activities against *Aspergillus* sp and also inhibited their mycelia growth (Ogunmoyole *et al.,* 2013). This generally confirmed that this seed is highly potent to activities of many microorganisms. *M. myristica* extracts inhibited the growth of mycelium and the formation of conidial spores and chlamydospores of *Sclerotium rolfsii*, thereby reducing the number of propagation units of this fungus in the medium (Mahesh and Satish, 2018). Ukaegbu-Obi *et al.*2015, reported that seeds extract of *M. myristica* possess some antimicrobial activities which can be employed in the development of novel therapeutic agents against the test organisms. Suwitchchayan and Kunasakdakul (2010) reported on the in vitro effects of clove in controlling crucifer pathogens. *Syzgium aromaticum* showed inhibitory effects on the pathogens. The results of the antifungal effect revealed that clove extract was indicated the minimum inhibitory concentration (MCI) of *Fusarium* sp, and *Aspergillus* sp at 1900 ppm and 2300 ppm respectively. The plant extracts differed in their potential to inhibit the growth of these fungal pathogens. This could be attributed to the difference in the bioactive compounds present in the botanicals studied. The greater efficiency of these plant extracts may be due to the phenolic substances they contain (Amienyo and Ataga, 2007), since they are ranked as the most efficient therapeutically significant plant substances (Okuwu and Igara, 2011). This result is also consistent with the findings of Santas *et al.,* (2010) who reported that plants have phenolic compounds and that their antifungal activity may be due to the action of the proteolytic enzymes which is their major component, as such have adverse effect on the protein component of fungal cells, hereby disrupting their growth. The *in vitro* and *in vivo* effects of *Syzgium aromaticum* (clove) and *Monodora myristica* ehuru/African Nutmeg) extracts were evaluated in order to develop cheaper methods of controlling post storage rot of onion bulbs.

CONCLUSION AND RECOMMENDATIONS

The findings from this study showed *Rhizopus* sp, *Fusarium* sp and *Aspergillus niger* to be the major fungal pathogens causing rot of onion bulbs and this was confirmed through a pathogenicty test which indicated that *Aspergillus niger* had the highest rot advancement for both white and red onion bulbs. The fungicidal activity of the extracts against *Fusarium* sp, *Rhizopus* sp and *Aspergillus niger*, showed the potential of clove (*Syzgium aromaticum*) and ehuru (*Monodora myristica*) as possible natural source of fungicidal materials and the efficacy of these extracts against the rot causing fungi were tested both in vivo and in vitro; the results from the experiment showed that plant extracts considerable inhibited the mycelia growth of the fungal isolates when compared with control. Furthermore, the crude plant extracts when applied before and after inoculation of the fungal isolates, significantly ($p \leq 0.05$) inhibited the growth on onions bulbs. Antifungal activity was confirmed in all the tested plant species, although the results showed that different plant extracts varied in their effectiveness in inhibiting the mycelia growth of different pathogens tested. The use of botanical products as alternative to chemical control of plant pathogens is possible. This approach can contribute in reducing the amount applied of fungicides and subsequently minimize its hazards to the environment and human health. These botanicals are also cheap, non- toxic, readily available and easy to use. The use of *Syzgium aromaticum* (clove) and *Monodora myristica* (ehuru/African Nutmeg) seeds should be encouraged as part of an integrated approach for the control of Onion bulb rot caused by *Rhizopus* sp, *Fusarium* sp and *Aspergillus niger*. Further investigation should be done on the chemical nature of the active components of the plants; also, further investigation can combine the plant extracts for possible synergistic effect.

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Nematodes Associated with *Citrullus lanatus* in Kwara State, Nigeria

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KEYWORDS

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ABSTRACT

The cultivation of watermelon is rapidly becoming popular in many areas of sub-Saharan Africa because of its economic and nutritional benefits. However, one of the factors limiting watermelon production is plant parasitic nematodes. This study was carried out to determine the abundance, occurrence, and distribution of nematodes infecting watermelon in some areas of Kwara State, Nigeria. A total of 96 root and soil samples were collected from 8 watermelon growing areas of the State, namely; Ajase-ipo 1, Ajase-ipo 2, Unilorin, Olomu, Eyenkorin, Onireke, Lafiaji 1, and Lafiagi 2. Extraction was done using a modified Baermann extraction tray method, while the nematodes were identified to genus level under a compound microscope. Five endoparasitic and ectoparasitic nematode genera were detected from the roots and soils; Meloidogyne, Pratylenchus, Scutellonema, Helicotylenchus, and Criconema. Results revealed that Meloidogyne spp. was the most prevalent nematode with 492.61 and 272.44 for the root and soil samples respectively. Meloidogyne spp. and Helicotylenchus spp. had the highest frequency of occurrence of 87.50% in the root, followed by Pratylenchus spp. with 62.50% and Scutellonema spp. with 50%. More nematodes were also recovered from the root than from the soil. This study provides fundamental information about the distribution of plant parasitic nematodes that infect watermelon in Kwara State.

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INTRODUCTION

Citrullus lanatus (Thumb.) Matsum and Nakai belong to the family Cucurbitaceae (Dantata, 2014). It is the most cultivated and consumed cucurbit in the world (Tunde, 2019; Anikwe *et al*., 2016). The fruit is greatly enjoyed because of its pleasurable taste and rich moisture, which can be used to assuage thirst (Mangila *et al*., 2007). It has a high level of lycopene which helps to lower cholesterol. The leaves are used as green vegetables in some areas while the juice of the roots can be used to stop hemorrhage after abortion. They contain antioxides which provide effective action against the free radicals in the body. Watermelon juice can be applied directly on the skin to minimize blemishes on the skin. The cultivation of watermelon is gradually becoming popular in Nigeria because of high demand thereby making it a good source of income for local farmers (Sabo *et al*., 2013). This also highlights the economic importance of the crop (Shehu *et al*., 2013). Some reports also show it is one of the most preferred fruits in Nigeria (Adeoye *et al*. 2011).

Despite the nutritional and economic benefits of watermelon, infection by pests and pathogens has been a major cause of poor growth and yield of the crop in Nigeria. The total watermelon production in Nigeria is estimated to be 139,223 tonnes (Abubakar *et al*., 2020). This is low when compared to production in other African countries like Algeria (2 million tonnes), Egypt (1.4 million tonnes), and their West African counterparts like Mali which produces about 396, 641 tonnes annually (World Atlas, 2023). A preliminary investigation showed that plant parasitic nematodes are one of the major pathogens limiting the production of the crop in Nigeria. Earlier studies showed that different nematode genera like *Meloidogyne, Helicotylenchus, Pratylenchus, Scutellonema, Criconema, Rotylenchulus, Longidorus,* and *Paratrichodorus* are associated with watermelon in Nigeria and other parts of the world (Bello *et al*., 2020). Of the entire nematode genera, root-knot nematode (RKN) appears to be the most prevalent economically important nematode of the crop. Alone, this nematode cause an annual loss estimated at $157 billion across different crops globally (Abad *et al*., 2008). There are indications that this figure is grossly underestimated in Africa because of a lack of awareness and inadequate assessment of the economic impact of nematodes on the continent (Onkendi *et al*., 2014). Unfortunately, there is a dearth of information about nematodes associated with watermelon in the Northern regions of the country which are the main producers of the fruit in the country.

This experiment was therefore carried out in some watermelon growing areas of Kwara State to identify nematodes that infect watermelon in the State. Kwara State is located in the North Central part of Nigeria and its proximity to both the Northern and Southern states indicates its strategic importance to food security in Nigeria and African continent.

MATERIALS AND METHODS

Discription of study area

The study was conducted in Kwara State, Nigeria (figure 1). The State has two main climatic seasons, the dry and wet seasons. Annual rainfall ranges between 1000 to 1500 mm while the average temperature lies between 30°C and 35°C. Kwara State falls within the Woodland and tall grass agroecological zone in Nigeria. The State is further divided into four main ecological zones in consonance with the ecological characteristics, cultural practices, and administrative convenience by the Kwara State Agricultural Development Program (ADP) as given below as Zone A: Baruteen and Kaima; Zone B: Edu and Patigi; Zone C: Asa, Ilorin East, Ilorin South, Ilorin West, and Moro; Zone D: Ekiti, Ifelodun, Irepodun, Isin, Offa, Oke-Ero and Oyun (KWADP, 2006).

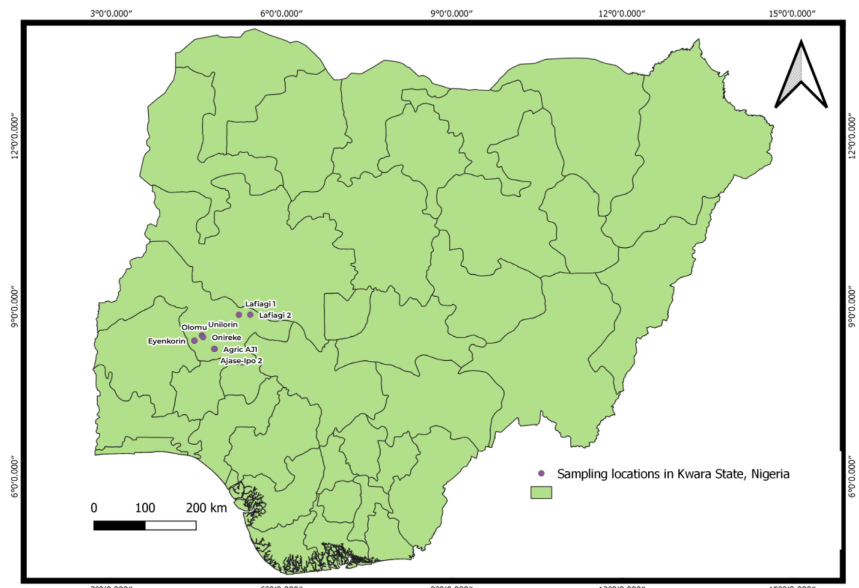

Figure 1: A map showing the locations where the watermelon survey was carried out in Kwara state, Nigeria

Sampling technique

The field sampling was carried out in three agroecological zones of the state which are the major watermelon-producing areas (Figure 1); Zone B, C, and D. The sampling was carried out between September to November 2017 cropping season. Criteria used for the selection of the survey area were availability of the farm, accessibility, and willingness of the farmer to allow sample collection on their farm. The average farm size in each location is not less than 2 hectares. All the farms visited intercrop watermelon with other crops; Ajase-Ipo (cucumber, tomato, pepper, cabbage, and maize), Eyenkorin (Palm tree and maize), Unilorin (cucumber), and Lafiagi (tomato). In each location, the Global positioning system (GPS) coordinate was recorded.

Collection of soil and root samples

Rhizospheric soil samples at a depth of 0 cm to 20 cm together with corresponding roots were collected from each location in a "W-shaped" pattern across each field. Soil samples from five plants spaced at an equal distance from each other were bulked together to ultimately obtain composite samples of six in each farm. These were collected in polyethylene sample bags, labeled accordingly, and transported for laboratory analyses (Bello *et al*., 2020). The soil and root samples were separated according to the location of each farm. The Global Positioning System (GPS) of the locations was also recorded

Extraction and morphological identification of nematode from soil and root samples

Soil samples were mixed thoroughly and a subsample of 250 ml was taken from each composite sample for nematode extraction and identification using the modified Baermann extraction tray method. Root samples were rinsed under a gentle stream of running water and blotted with tissue paper (Coyne *et al*., 2007). The cleaned root was chopped into 0.5 cm to 1 cm and macerated with a blender for 5 seconds. A subsample of 10 g was taken for nematode extraction and identification using the modified Baermann extraction tray method as described above. After 48 hours, the number of nematode populations in 2ml suspension was counted three times using Doncaster counting dish (Doncaster, 1962), and the average was used to estimate the nematode population. Each nematode genus was identified using the CABI Crop Protection Compendium (CABI, 2007) and diagnostic keys, under a compound microscope (Coyne *et al*., 2007).

Determination of Prominence Value (PV)

The Prominence value for the nematode genus identified was determined using the formula;
Prominence value = (mean population density ×√frequency of occurrence) ÷ 10
Where,
Mean population density (MPD) = total number of nematodes ÷ number of samples obtained.
Frequency of occurrence (FO) = (number of samples containing a nematode species ÷ number of samples collected) × 100.

RESULTS

Results showed that watermelon was planted as a mixed crop in the majority of the area visited. Some major crops planted along the crop include Cucumber, tomato, pepper, Maize, cabbage, and maize (table 1).

Table 1: Locations, GPS and farming system practiced in sampled watermelon growing areas of Kwara State, Nigeria

Location	GPS	Alternative crop	Farming system
Ajase-ipo_1	8°23’33’’N 4°35’55’’E	Cucumber, tomato, pepper	Mixed
Ajase-ipo_2	8°14’47’’N 4°49’19’’E	Cucumber, tomato, pepper, cabbage and maize	Mixed
Olomu	8°26’16’’N 4°26’1’’E	Palm tree and maize	Mixed
Eyenkorin	8°23’38’’N 4°27’55’’E	Cassava and maize	Mixed
Unilorin	8°26’57’’N 4°39’52’’E	Cucumber	Mixed
Onireke	8°26’52’’N 4°36’36’’E	Cucumber, Maize	Mixed
Lafiagi	8°50’56”N 5°24’58’’E	–	Sole
Lafiagi_2	8°51’10’’N 5°24’59’’ E	Tomato	Mixed

Five nematode genera were identified from the sampled root and soil; *Meloidogyne, Pratylenchus, Scutellonema, Helicotylenchus,* and *Criconema.* Results revealed that *Meloidogyne* was the most prevalent nematode with a PV of 492.61 and 272.44 for the root and soil samples respectively (table 2). This was followed by *Helicotylenchus, Pratylenchus,* and *Scutellonema*. Whereas *Criconema* was not detected inside the root, it recorded the lowest PV of 1.88 in the soil. Data also revealed variations in the frequency of occurence among different nematode genera from different locations. *Meloidogyne* and *Helicotylenchus* had the highest FO of 87.50% in the root, followed by *Pratylenchus* with 62.50% and *Scutellonema* with 50%. Similarly, *Meloiogyne* had the highest occurrence in the soil (87%) while *Pratylenchus* and *Helicotylenchus* occurred in 75% of the locations. *Criconema* had the least occurrence of 25%. The mean population density (MPD) analysis further established *Meloidogyne* as the most abundant nematode in both the root and soil samples.

Table 2: Prominence value (PV), Frequency of occurrence (FO), and Mean population density (MPD) of plant parasitic nematodes recovered from watermelon fields in 8 locations across Kwara state, Nigeria

	Root			Soil		
	MPD	FO (%)	PV	MPD	FO (%)	PV
Meloidogyne	526.88	87.50	492.61	291.25	87.50	272.44
Pratylenchus	30.63	62.50	24.21	18.75	75.00	16.24
Scutellonema	18.13	50.00	12.82	12.50	62.50	9.88
Helicotylencus	140.63	87.50	131.54	91.25	75.00	79.02
Criconema	0.00	0.00	0.00	3.75	25.00	1.88

Generally, the highest population of nematodes was recorded in Ajase-ipo_1 and followed by Unilorin in both root and soil samples. In contrast, the location with the least nematode abundance in both samples was Lafiagi_2.

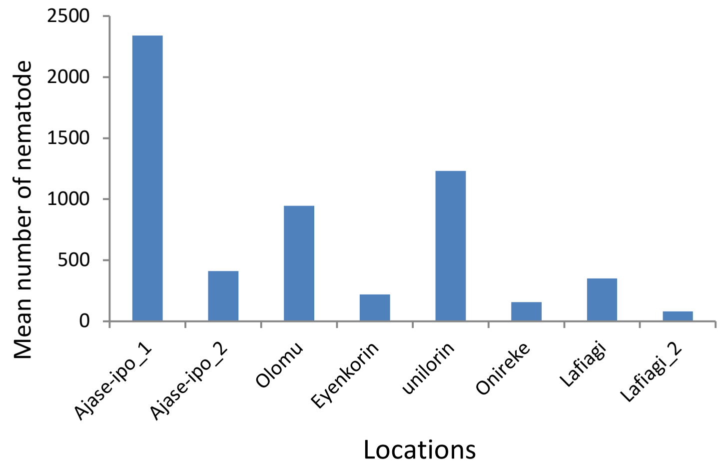

Figure 2: Mean population density of nematode recovered from the root of watermelon across different areas of Kwara State

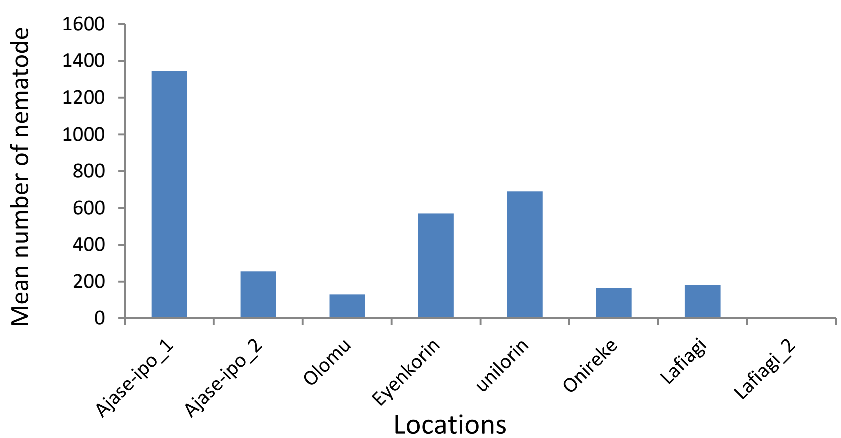

Figure 3: Mean population density recovered from the soil of watermelon across different areas of Kwara state during

On the whole, more nematodes were recovered from the root samples than soil samples (Fig 4 and 5).

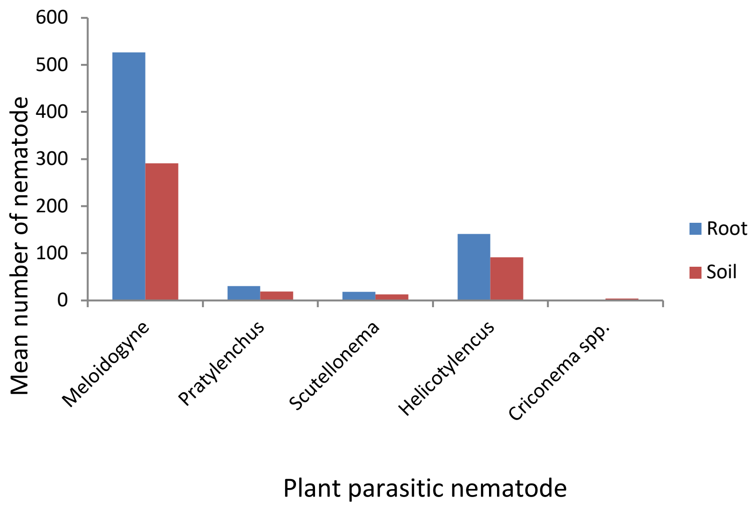

Figure 4: Mean population density of nematode recovered from the root and soil of watermelon planted in different locations of Kwara State

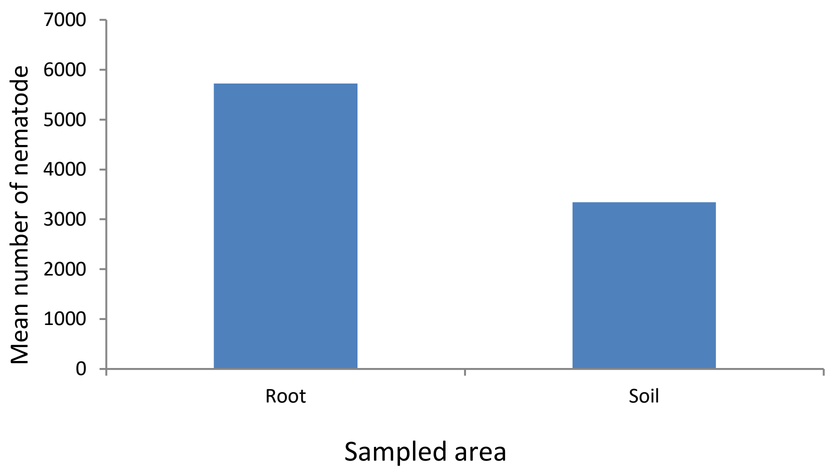

Figure 5: Mean nematode population recovered from the root and the soil from different watermelon growing areas of Kwara State

DISCUSSION

This study provides relevant information about the occurrence of parasitic nematodes on watermelon in Kwara State, Nigeria. The presence of both ectoparasitic and endoparasitic nematodes showed the susceptibility of watermelon to different nematode genera and the ability of the pathogen to cause a reduction in both the growth and yield of watermelon on the field. It is also worrisome that all the five nematode genera sampled in this study were found in mixed infection. Before this study, each of the nematode genera identified has also been found to be associated with other crops in Sub-Saharan Africa and other continents of the world (Kolombia *et al*., 2020; Marais, 2019), nevertheless, this work is providing relevant information on watermelon nematodes in a region where there is a paucity of information. *Meloidogyne* was detected as the most prevalent nematode genus across locations in this study. The findings of this experiment are similar to Bello *et al.* (2020), who also reported the presence of nematodes on the field of watermelon in the southwestern states of Nigeria. The nematode (*Meloidogyne* spp.) has been previously named as the most damaging nematode genera in plants with a wide range of hosts (Lunt *et al.*, 2014). Across Africa, twenty-two (22) species of root-knot nematode have been reported on several plants including vegetables, fruits, and tree crops (Onkendi *et al.*, 2014).

Previously, the high prevalence of *Meloidogyne* in the field is usually attributed to factors like cultural practices, cropping history, and soil type (Anwar and Mckenry, 2012; Eche *et al*., 2013). In most of the places sampled during this study, watermelon was planted alongside other crops which are also natural hosts of *Meloidogyne*. In this case, it could be inferred that planting alternate hosts besides the watermelon field could have led to a surge in the population density of the pathogen (Alabi *et al*., 2017). This is similar to the observation of Seid *et al*. (2015), where they observed a higher population density of *Meloidogyne* in places where Khat was intercropped with tomato, pepper, potato, cabbage, and maize. Another factor that could have led to an increase in the population density of *Meloidogyne* is the cropping history of the field (Eche *et al*., 2013). Higher nematode population was observed in locations where there was continuous cultivation over the years and no interruption (Unilorin, Agric AJ1, Agric AJ1, Olomu, and Eyenkorin). The practice of continuous production allows a buildup of nematode over time and particularly, *Meloidogyne* which has an extensive range of hosts (McClure *et al*., 2012) and could have survived in the soil over time in those locations. This is also similar to the observation of Afolami *et al*. (2014), when they investigated the activities of some nematode genera on sugarcane. They reported a high population on the field as a result of using the field continuously. The life cycle of the nematode is also a factor that could have caused an increased prevalence of the nematode. Under favourable environmental conditions, an adult female of *Meloidogyne* can produce more than 50 to 1000 eggs which also gives them numerical strength that increase their chances of surviving (Hussain *et al*., 2016). The findings of this experiment is in congruence with earlier reports by Izuogu *et al*. (2016), who reported extensively on the effects of *Meloidogyne* on cucurbits in Kwara state, Nigeria. The recovery of endoparasitic *Pratylenchus* and *Scutellonema* in the root also showed the susceptibility of the varieties cultivated in the locations. The recovery of more nematodes from the root than soil across all locations showed the susceptibility of watermelon roots to endoparasitic nematodes.

CONCLUSION

The knowledge from this study has established the major nematode genera infecting watermelon in Kwara State Nigeria. It was also discovered that *Meloidogyne* is the most ubiquitous across the field in the State.

ACKNOWLEDGEMENT

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Conflicts of Interest: We state that there is no conflict of interest whatsoever on this research work.

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Effect of *Carica papaya* Extract on Seed Borne Fungal Organism of African Yam Bean (*Sphenostylis stenocarpa* Hochst ex. A. Rich. Harms) Seeds

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K E Y W O R D S

African yam bean,
Carica papaya,
Fungal organism,
In-vitro,
Seed health,
Radial growth inhibition

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A B S T R A C T

Extracts of many higher plants have been reported to exhibit antifungal properties under Laboratory experiment. This study was therefore carried out to investigate the effect of Carica papaya plant extracts on seed borne pathogen of African yam bean. Seed health test of African yam bean was carried out using blotter paper method. Test of plant extract for inhibition of radial growth of seed borne pathogen of African yam bean was studied under in-vitro experiment at 0%, 50%, 75% and 100% concentrations with 0% as the control. The design used was a completely randomized design (CRD) with three replications. The test plant extracts of different concentrations were added into petri dishes containing molten sterilized Sabouraud Dextrose Agar (SDA) and swayed gently on the Laboratory bench to allow even mixing. These were allowed to gel. Then nine-millimeter discs of a seven-day pure culture of Aspergillus flavus were aseptically placed on the center of the petri dishes containing the SDA-extract mixture. Record on radial inhibition effect of the test plant extract was kept for further analysis. Analysis of variance (ANOVA) was conducted on data on radial inhibition of test fungus. Results showed that Aspergillus niger, Aspergillus flavus and Aspergillus terreus were isolated from incubated African yam bean seeds. Results also showed that Carica papaya leaf extract used was very effective and the higher the concentrations of extract, the more effective in the inhibition of radial growth of the test fungal organism. It could therefore be recommended that farmers should always conduct viability test on procured seeds for planting. That farmers should rather use plant extract such as was used in this investigation if stabilized in controlling seed borne fungal pathogens of African yam bean seeds than synthetic fungicides.

INTRODUCTION

African yam bean (AYB) *Sphenostylis stenocarpa*, belongs to the legume family. It originated in Ethiopia (Busson, 2001), but both wild and cultivated types now occur in tropical Africa as far north as Egypt and also throughout West Africa from Guinea to Southern Africa. It is cultivated in Nigeria mainly for seed and also grown for tubers in Cote d'Ivoire, Ghana, Togo, Cameroon, Gabon and Democratic Republic (Utter, 2007). The African yam bean (*Sphenostylis stenocarpa*) is a climbing legume that grows to a height of over 3m and is adapted to low land tropical conditions. It is one of the lesser-known legumes (Ikhajiagbe *et al.*, 2007a, b; Apata and Ologhobo,1990). Different authors over the years have reported the proximate composition of African yam bean with varying values over the years, Carbohydrate (49.88–63.51%) and protein (19.53–29.53%) are the major components of AYB, while other components such as ash (1.86–5.35%), fat (1.39–7.53%) and fibre (2.47–9.57%) are present in relatively small amounts (Adeyeye *et al*., 1994). African yam bean (*Sphenostylis stenocarpa*) is a hard-to-cook under exploited leguminous plant grown extensively in Western Africa (Enujiugha *et al*, 2012; Uchegbu, 2015). For efficient growth of this crop there is need for seed viability test. Seed health is a measure of freedom of seeds from pathogens. The presence or absence of seed-borne pathogens can be confirmed through the use of seed health testing (Agrawal,1997). The term "seed health" include the incidence in the seed lot of fungi, bacteria, viruses, and animal pests such as nematodes and insects. The test used depends on the organism being tested for and the purpose of the test quality assurance or phytosanitary purposes when seed is exported (ISTA, 2015). It includes visual examination of seeds externally or internally, macro or microscopically for the presence of pathogens as well as incubating seeds on agar or moist blotter papers and identifying the pathogens microscopically (Warham *et al*.,1990). In seed health testing for seed borne fungi pathogens the blotter test is no doubt one of the most important method available (limonard,1966). Blotter tests are similar to germination test in that seeds are placed on moistened layers of blotter and incubated under conditions that promote fungal growth. The demand for the biological control of pathogens using plant extracts containing secondary metabolites has been a common practice for thousands of years (Chavez-Quintal *et al*.,2011; Hewajulige, Dhekney, 2016). Papaya (*Carica papayaL*.) belongs to the family Caricaceae and is the most economically important species of the genus *Carica*. (Hewajulige, Dhekney,2016) Papaya is native to tropical America, and seeds of papaya were taken from the Caribbean, to Malacca or Philippines, then to India. Subsequently, papaya was introduced as a plantation crop to Australia, Hawaii, Sri Lanka, and other tropical and subtropical countries in the world (Hewajulige, Dhekmeg, 2016). The papaya plant, including fruit, leaf, seed, bark, latex, and their ingredients play a major role in the management of disease progression. *Carica papaya* leaf contains active components such as alkaloids, glycosides, tannins, saponins, and flavonoids, which are responsible for its medicinal activity.

MATERIALS AND METHODS

Germination test and seed health test: Germination test was carried out to investigate the rates at which the test samples germinate and also seed health test was carried out to investigate the seed borne pathogen of the test sample. The percentage germination of African yam bean seed was determined by this formula:

$$\frac{\text{Number of germinated seeds}}{\text{Total number of seeds}} \quad \frac{\text{x}100}{1}$$

The percentage infection of African yam bean seed was determined by this formula:

$$\frac{\text{Number of infected seeds}}{\text{Total number of seeds}} \text{ x } \frac{100}{1}$$

Seed health test: Seed health test for seed borne fungi was carried out following the rules of international seed testing association (ISTA, 2001). Standard blotter method was used for this study. In the blotter paper method, 12 seeds each was randomly taken from the 204 seeds. The seeds were sterilized with a mixture of 10ml of ethanol and 90ml of water (10% ethanol) for 3 minutes and rinsed two times with sterile distilled water in order to effectively remove surface contamination without affecting the germination percentage of African yam bean seeds (Pernezny *et al*, 2002). Twelve seeds of African yam beans were plated in each 9cm petri-dish containing three layers of Whatman filter paper wetted with distilled sterile water. Seeds were arranged according to international seed testing association (ISTA, 2001). Seventeen petri-dishes were used for the sample. The twelve seeds of African yam bean in a plate were arranged seven seeds at the outer ring, four seeds at the middle ring and 1 seed in the inner ring. More water was added to rewet the paper after initial wetting after some dryness was experienced. The petri-dish were sealed up using masking tape and labeled properly. The plates were placed on the Laboratory working bench which was first sterilized with methylated spirit to ensure an aseptic condition. Germination and infection counts were observed for seven days from the second day after plating. Germination and infection counts were recorded every day until the seventh day. Fungal growth was observed on the plates based on the mycelia colour and hyphal growth.

Culturing of fungal organisms from infected seeds: Seeds infected with fungal organisms were isolated from the plated seeds and transferred into Sabouraud dextrose agar (SDA) medium. The organisms were incubated in triplicate plates at 28°C ±2 for seven days. Sub-culturing of isolated fungal organisms was done using SDA media to obtain pure cultures, which were kept properly for further investigation.

Plate1: Plated seeds of AYB on day1

Plate 2: Germinated seeds

Plate 3: Infected seeds of African yam bean

Microscopic identification of isolated fungal organisms: Temporary slides of isolated fungal organisms were made by placing small portion of the mycelia of each fungus taken from the part active growth on the sterile glass slides having some drops of lactophenol in cotton blue and the slides were covered with a cover slip. The prepared slides were viewed under a compound microscope model (Olympus-XN50). Identification of the fungal organisms was based on the culture growth patterns, colour of mycelia and microscopic examination of vegetative and reproductive structures. Micrographs of the organisms were also taken and recorded.

***In- vitro* effect of different concentrations of *Carica papaya* plant leaf extract:** Different concentrates of the agar extract mixture were dispensed into 9cm petri-dishes and allowed to gel and then inoculated centrally with 0.9cm diameter mycelial discs obtained from seven- days pure culture of *Aspergillus flavus with* a sterilized cork-borer and placed at the center of each petri-dish. Two perpendicular lines were marked thinly on the base of the petri-dish with a marker and passing through the center of the petri-dish to serve as reference for measuring growth. All plates were placed on a Laboratory bench and at a room temp of 28 ± 2°C. Radial growths along each line were measured at exactly 24hrs interval with a meter rule to determine the radial growth inhibition. The radial growth inhibitions in each plate were measured for 7 days. Each treatment was replicated three times. Percentage radial inhibition was determined according to (Sundar *et al,* 1995) thus: Percentage radial inhibition = $\frac{dc-dt}{dc}$ x $\frac{100}{1}$ Amadioha (2003). Where dc = control,

dt = treatment.

Experimental design/Data analysis: The experiment was laid out in a completely randomized design (CRD) and replicated three times. Data collected were subjected to analysis of variance (ANOVA) and means were separated using least significance difference (LSD) at 5% probability level. GenStat release 10.3 version was used for all the statistical analysis

RESULTS

Germination and infection percentage of plated African yam bean (*Sphenostylis stenocarpa*)

The germination and infection percentages of S*phenostylis stenocarpa* were calculated for seven days. Having seventeen petri-dishes, each having twelve seeds. Germination and infection percentages were calculated for each petri-dish for the period of seven days. The highest germination percentage was recorded as 92% in replicate 4 on the 6th and 7th day, followed by 83% in replicate 7 on the 6th and 7th day. The highest infection percentage was recorded at 50% in replicate 7 on the 6th and 7th day From day 1 till day 3, no germination was seen; therefore, there was 0% germination in the 17 petri-dishes for that period.

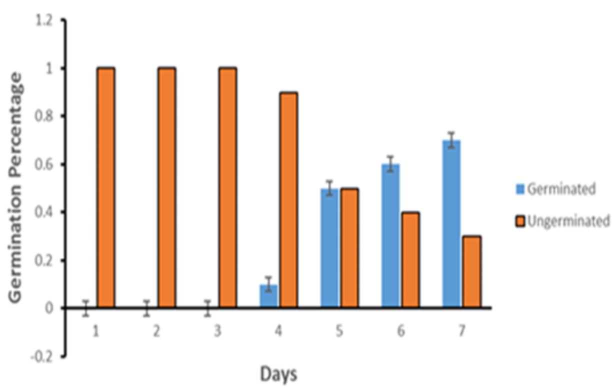

Figure 1: Percentage germination of African Yam Bean for seven (7) days

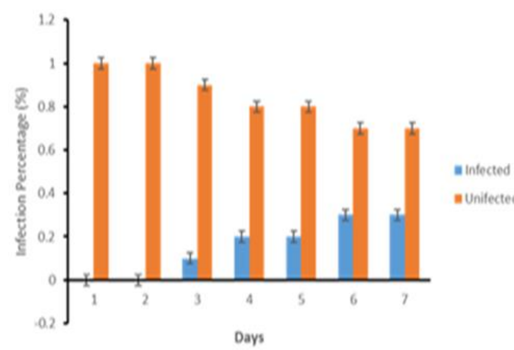

Figure 2: Percentage Infection of African Yam Bean for seven (7) days

Fungal isolation and identification: The result of isolation and identification of fungal seed borne organisms showed that *Aspergillus niger*, *Aspergillus flavus* and *Aspergillus terreus* were implicated.

Plate 4: *Aspergillus niger*

Plate 5: Micrograph of *Aspergillus niger*

Plate 6: *Aspergillus flavus*

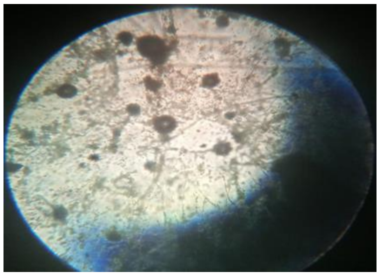

Plate 7: Micrograph of *Aspergillus flavus*

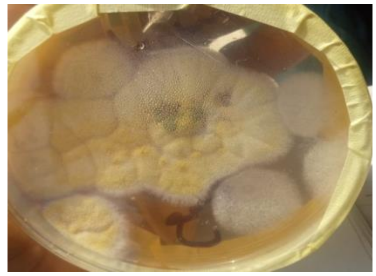

Plate 8: *Aspergillus terreus*

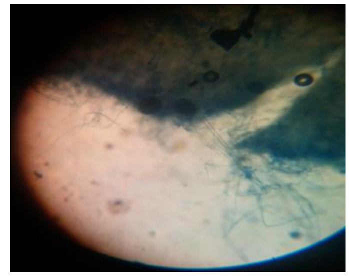

Plate 9: Micrograph of *Aspergillus terreus*

Effect of plant extract, their concentration on the percentage inhibition on the radial growth of *Aspergillus flavus*: Result of phytotoxic effect of *Carica papaya* plant leaf extract showed that there was significant inhibitory effect of the extract on radial growth of *Aspergillus flavus* in culture. Also, the result showed that there was significant difference among the effects of the various concentrations in inhibiting the growth of the test organism in culture. On day two, concentration of 100% had the highest (86.7%) inhibition followed by 75.0% obtained in concentration of 75% while the least (62.3%) inhibition was observed in 50% concentration level. All the three concentrations performed better than the control. This trend was observed in day three till the seventh days

Table 1: Effect of *Carica papaya* plant extracts by Soxhlet extractions, their concentration and percentage inhibition on the growth of *Aspergillus flavus* from day 1 to 7

Concentration and Percentage inhibition of *Aspergillus flavus* in culture							
Con (%)	**Day1**	**Day2**	**Day3**	**Day4**	**Day5**	**Day6**	**Day7**
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
50.00	0.00	62.3	57.67	78.33	78.67	67.70	34.70
75.00	0.00	75.0	73.67	85.00	84.00	82.0	72.00
100.00	0.00	86.7	83.67	90.67	88.00	88.00	88.00
Grand Mean	0.00	56.0	53.75	63.50	62,67	59.40	48.80
$LSD_{0.05}$	0.00	8.78	6.32	3.72	3.95	10.11	18.14

DISCUSSION

The result of the germination test showed that germination of African yam bean is not instant; it takes 3 or 4 days before germination starts. Seed treatment is the safest and the cheapest way of control of seed-borne fungal diseases and to prevent bio-deterioration of grains (Chandler 2005; Bagga and Sharma 2006). The efficiency of four seed health testing techniques namely the blotter, deep-freezing blotter, ragdoll and agar plate methods in detecting seed-borne fungi of African yam bean, *Sphenostylis stenocarpa* seeds was evaluated and the blotter method was found to be the most suitable testing technique for detecting Aspergilus *flavus, A niger, A terreus.* Ora *et al*. (2011) reported that the seed health testing in seed companies as well as those working in Research and quarantine departments becomes about 90% of the food crops grown world-wide and the plant germplasm being distributed between and within countries are propagated by true seeds (Neergaard, 1979). Many plants pathogen (bacteria, fungi, nematodes and viruses) affecting the food crop and plant germplasm are seed borne and seed transmitted.

Isolation of seedborne fungal organisms: The result on isolation and identification of seedborne fungal organisms from *Sphenostylis sternocarpa* showed that *Aspergillus* species were implicated which included: *Aspergillus niger*, *Aspergillus flavus* and *Aspergillus teureus.* This is similar to results of Iwuagwu *et. al* (2019) and Iwuagwu *et al* (2022), who isolated *Aspergillus niger* from seeds of **Vigna subterranean** and *Citrullus lanatus* respectively

Phytotoxic effect of *Carica papaya* plant leaf extract on radial growth of *Aspergillus*

Flavus: The result of the effects of C*arica papaya* leaf extract on inhibition of radial growth of *Aspergillus flavus* isolated from *Sphenostylis sternocarpa* showed that 50% had the lowest fungal radial growth inhibition compared to C*arica papaya* leaf extract concentration of 75% and 100%. This corroborates Olubode *et al* (2018), who reported exhibition of antifungal properties of *Carica papaya* leaf extract against *Aspergillus niger* and *Aspergillus flavus* under laboratory trails. This is also in line with works of Aliero and Afolayan (2006), who also reported antimicrobial activity of *Solanum tomentosum.* Parekh *et al.* (2006) and Iwuagwu *et al* (2022) have as well reported about efficacy of aqueous and methanol extracts of some medicinal plants for potential antibacterial activity against seedborne pathogenic fungi

CONCLUSION

From the experiment it was observed that all organisms isolated were *Aspergillus species* Therefore, it could be said that fungal organism were the major cause of seeds deterioration of African yam bean, It could also be inferred that seeds deterioration caused by *Aspergillus spp*, leads to poor visibility and loss of seedling vigour. The *Carica papaya* extract used was very effective in inhibiting *Aspergillus flavus* in culture. It was also observed that the higher the concentrations of the extract, the more the effectiveness in inhibition of radial growth of the fungal organism

RECOMMENDATIONS

Having seen that African yam bean losses viability when infected, it could therefore be recommended that farmers should always source their seeds from certified seed outlets. Also, farmers should always conduct viability test before sowing to ensure adequate plant establishment in the field. Farmers should rather than using synthetic protective chemicals which are detrimental to human health and environment use plant extracts such as was tested in this research to control fungal diseases, which are also readily available.

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Evaluation of the Effect of Diet Containing Cinnamon and Red Pepper on Serum Biochemistry and Hematological Indices of Broiler

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K E Y W O R D S

Broiler,
Cinnamon,
Hematology,
Red paper,
Serum biochemistry

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A B S T R A C T

This study was conducted to evaluate the effect of diet containing cinnamon and red pepper on serum biochemistry and hematological indices of broiler. One hundred and twenty (120) day old broiler chicks (Ross 308) were randomly divided into 4 treatment groups and 3 replicates of 10 birds per replicate in a completely randomized design. A mixture of cinnamon and red pepper at the ratio of 1:1was put in broiler diets at 0%, 0.5%, 1.0% and 1.5% at starter and finisher stages and were fed to broilers for 8 weeks. At the end of the experiment, 3 birds per replicate were selected and used for analyses of serum biochemistry and haematological indices. Results of serum biochemistry showed significant (P <0.05) effects of dietary cinnamon and red pepper inclusion on Cholesterol, aspartate aminotransferase, creatinine, urea, alkaline phosphatese, alanine aminotransferase, total protein, albumin, glucose, red blood cell count, white blood cell count, hemoglobin, packed cell volume, mean cell hemoglobin, neutrophils, platelet, mean cell volume and mean cell haemoglobin concentration. The results of the experiment showed that cholesterol and urea levels decreased as the level of cinnamon and red pepper increased but treatment three had the normal cholesterol level for broiler. Therefore, cinnamon and red pepper mixture should be included at 1.0% for optimum growth and performance of broiler birds.

INTRODUCTION

Protein from animal is important in human nutrition due to its high level of amino acid content (Tewe, 1997). Animal proteins have higher essential amino acids than plant protein. Malnutrition as a result of deficiency of vital nutrients has been an issue of serious concern in most areas of Africa (Agunbiade *et al*., 2000). Avaliable information indicates that poultry production is the fastest means of bridging the animal protein deficit in Africa (Oluyemi and Roberts, 1988). This is because, poultry has a short production period, a high rate of reproduction, and is distinguished by relatively high efficiency of nutrient modification into quality animal protein (Akinfala *et al*., 1999). Broiler production is considered most profitable in poultry industry. Broilers are bred as mixed-sex flocks in large intensive conditions (Olaifa *et al.,* 2019). Farmers can raise broilers severally in batches within a year and in large numbers in order to meet the demand for an ever increasing human population. Phytobiotics are natural bioactive compounds that are got from plants and included in animal feed or water as an extract to promote productivity through the improvement of digestibility, nutrient absorption, and elimination of pathogens found in the alimentary canal of animal. Red pepper is commonly used in diet and traditional medicine. It is a good source of protein and also reduces the cholesterol level for having antioxidant potential. It has antimicrobial peptides which are very efficient in inhibiting growth in human and plant pathogenic bacteria and fungi. It is very rich in vitamin C and pro-vitamin A and B and it is very high in potassium, magnesium, and iron. The substances that give hot pepper the heat are capsaicin and several related chemicals collectively called capsaicinoids. These two phytobiotics with their amazing properties can therefore work in synergy to improve the Serum biochemical and hematological indices of broiler which are reliable indicators of the health status of animals and may have vital roles in prognosis, diagnosis and treatments of poultry diseases.

MATERIALS AND METHODS

Study Location:The study was carried out at the poultry unit of the teaching and research farm of the Department of Animal Science and Technology Nnamdi Azikiwe University, Awka Anambra state.The location lies between latitude 6.24°N and 6.28°N and Longitude 7.00°E and 7.08°E on the southeastern part of Nigeria. The climatic condition is the tropical wet and dry type with a clear season. The mean daily maximum temperature is usually 27°c all-round the year and can be 34°c in March. The mean annual rainfall is about 1600m according to the local meteorological station which has maintained records since 1978 with a relative humidity of 80% at night.

Collection and Processing of Cinnamon and Red Pepper: Air dried cinnamon bark and red pepper were procured from commercial dealers. The air-dried cinnamon and red pepper were milled into fine particles using a local milling machine. The ground samples were stored in an airtight container under room temperature (23.1 – 24.6 ^{0}C).

Experimental Diets*:* According to the Hubbard classic nutrient requirements, two basal diets were formulated and offered as broiler starter diet (0 - 28 days of age) and broiler finisher diets (28 to 56 days of age). Cinnamon and red pepper were mixed at the ratio of 1:1 and the mixture was included at 0, 0.5, 1 and 1.5% levels to represent T1,T2, T3 and T4 respectively in the ration of starter and finisher to form eight different treatment diets. The feed ingredients and composition of starter and finisher diets are presented in Table 1 and 2.

Table 1: Composition of broiler starter diets containing different inclusion levels of cinnamon and red pepper mixture.

INGREDIENTS	T1 (0%)	T2 (0.5%)	T3 (1.0%)	T4 (1.5%)
Maize	44	43	42	40.5
Wheat offal	8	8	8	8
Rice bran	6	6	6	6
Soybean meal	20	18.5	17	16
Fish meal	4	4	4	4
Groundnut cake	10	12	14	16
Bone meal	3	3	3	3
Oyster shell	3	3	3	3
Salt	0.5	0.5	0.5	0.5
Cinnamon + red pepper mixture	0	0.5	1.0	1.5
Lysine	0.5	0.5	0.5	0.5
Methionine	0.5	0.5	0.5	0.5
Vit/min premix	0.5	0.5	0.5	0.5
Total	100	100	100	100
Calculated Crude protein (%)	22.16	22.10	22.04	22.00
Calculated ME (kcal/kg)	2700.00	2700.00	2700.00	2700.00
Analysed crude protein (%)	21.38	21.00	21.7	21.2
Analysed ME (kcal/kg)	2677.00	2650.00	2630.00	2690.00

Table 2: Composition of broiler finisher diet containing different inclusion levels of cinnamon and red pepper mixture**.**

INGREDIENTS	T1 (0%)	T2 (0.5%)	T3 (1.0%)	T4 (1.5%)
Maize	49	47	45	43
Wheat offal	9	9	9	9
Rice bran	6	6	6	6
Soybean meal	20	20	20	20
Fish meal	4	4	4	4
Groundnut cake	4	5.5	7	8.5
Bone meal	3	3	3	3
Oyster shell	3	3	3	3
Salt	0.5	0.5	0.5	0.5
Cinnamon+red pepper mixture	0	0.5	1.0	1.5
Lysine	0.5	0.5	0.5	0.5
Methionine	0.5	0.5	0.5	0.5
Vit/min premix	0.5	0.5	0.5	0.5
Total	100	100	100	100
Calculated Crude protein(%)	20.20	20.05	20.01	20.00
Calculated ME(Kcal/kg)	3000.00	3000.00	3000.00	3000.00
Analysed crude protein (%)	19.50	19.60	19.00	19.80
Analysed ME (kcal/kg)	2900.00	2900.50	2998.00	2950.00

Experimental Birds: One hundred and twenty (120) unsexed day-old broiler chicks (Ross 308) were used in this study. The broiler chicks were procured from AGRITED hatchery Ibadan, Oyo state through their state distributor.

Experimental Design: Complete randomized design was used in the study. One hundred and twenty (120) broiler chicks were divided into four treatment groups. Each treatment contained 30 chicks and was randomly subdivided into 3 replicates with 10 chicks per replicate. Each treatment group was assigned to each of the treatment diets.

Experimental Procedure: Blood collection: Birds in each replicate pen were reared in individual pen. On the 56th day of study, blood samples were randomly collected from four birds per treatment. Blood samples of 2ml were collected via the wing veins using sterile needles and syringes. The blood samples were put in properly labeled and sterilized anticoagulant (EDTA) tubes and used for hematological analysis. Also, 2ml of blood was collected from each bird and was put into tubes without anticoagulant, for estimation of serum biochemistry. The blood samples inside tubes without coagulant were placed in a slanting position at room temperature for 6 h and incubated overnight in the refrigerator at 4°C to obtain serum. The serum samples were kept at -20 °C before biochemical analysis.

Assessment of serum biochemistry indices: The following biochemistry analyses were estimated: total protein, albumin, creatinine, glucose, cholesterol, urea, AST, ALT, ALP,

Evaluation of hematological indices: The samples were subjected to hematological analysis which included hemoglobin (Hb) concentration, red blood cells (RBC), packed cell volume (PCV), mean cell hemoglobin (MCH), mean cell HB concentration (MCHC), white blood cells (WBC), mean cell volume (MCV), neutrophils, lymphocytes (LY), using Hematological Analyzer Sysmex XP- 100 (Japan).

Statistical Analysis: Data generated were subjected to one way analysis of variance (ANOVA). Differences ($P<0.05$) between treatments means where observed were separated using Duncan's multiple range test (DMRT) as outlined by (Steel *et al*., 1997).

RESULTS AND DISCUSSION

Haematological indices of broiler finisher birds fed diets containing different levels of cinnamon and red pepper mixture.

The effects of different levels of inclusion of cinnamon and red pepper mixture on haematological indices of broiler finisher are shown in Table 3.

Table 3: Haematological indices of broiler finisher birds fed diets containing different levels of cinnamon and red pepper mixture

PARAMETERS	TREATMENTS				
	T (0%)	T2 (0.5%)	T3 (1%)	T4 (1.5%)	P value
Hemoglobin (Hp)	12.03^{b}	13.17^{d}	12.97^{c}	11.03^{a}	0.00
Pack Cell Volum (Pcv)	35.00^{a}	38.43^{b}	39.07^{b}	34.00^{a}	0.00
Red Blood Cell (Rbc)	2.51^{a}	2.49^{a}	2.63^{b}	2.82^{c}	0.00
White Blood Cell (Wbc)	194.17^{c}	192.57^{b}	202.87^{d}	47.43^{a}	0.00
MCH	50.77^{a}	52.67^{c}	52.1O^{b}	50.70^{a}	0.00
MCV	146.10^{b}	138.33^{a}	138.37^{a}	147.20^{b}	0.00
MCHC	34.50^{a}	38.10^{c}	37.73^{b}	34.57^{a}	0.00
Platelets	28.00^{b}	17.00^{a}	15.33^{a}	45.67^{c}	0.00
Lymphocyte	2.97^{c}	1.00^{a}	2.00^{b}	1.00^{a}	0.00
Neutrophils	96.20^{b}	97.13^{c}	94.17^{a}	96.23^{b}	0.00

a,b,c,d Means on the same row bearing different superscripts are significantly different ($P < 0.05$)

Hemoglobin, packed cell volume, red blood cell count, White blood cell count, Mean cell hemoglobin concentration, Lymphocyte, platelets and neutrophilis showed significant differences ($p<0.05$) among treatment groups for 8 weeks old broiler birds. The findings in this study agreed with the results of Reiss *et al* (2018), who reported that inclusion of phytochemicals such as cinnamic aldehyde, thymol and carvaacrol in broiler birds significantly increased red blood cell counts and haemoglobin in comparism with the control group. Similar findings in another study were reported by krauze *et al.,* (2020) who studied the dietary effects of probiotic, bacillus subtilis (0.25g/l) enterococcus faecium 0.25g/l), and phytobiotics containing cinnanmon oil (0.25g/l) in broiler birds and found improvements in the immune system and parameters such as red blood cell count and hemoglobin.

The RBC values, WBC, MCH, MCV and MCHC values obtained for the birds in this study were higher than value reported for normal chicken by Mitruka *et al*., (1997) and also higher than the one reported by (Orawan *et al*., 2007).

The number of red blood cells in chicken influences the overall conditions of the birds.

Therefore, the increases in packed cell volume, Hemoglobin and erythrocyte counts of the birds fed the test ingredients are indication that the oxygen carrying capacity of the blood was improved. A decrease in the hemoglobin, mean corpuscular volume, and MCH levels in birds is also an indication that the birds were exposed to stressors (Huff *et al*., 2008).

Dietary additive of cinnamon and red pepper mixture improved the blood cells suggesting better utilization of the dietary nutrients.

Serum biochemistry indices of broiler birds fed diets containing different levels of cinnamon and red pepper mixture

The effects of cinnamon and red pepper on serum biochemistry of broiler at finisher phase are shown in Table 4.

table 4: Serum biochemistry indices of broiler birds fed diets containing different levels of cinnamon and red pepper mixture

PARAMETERS	TREATMENTS				
	T1 (0%)	T2 (0.5%)	T3 (1%)	T4 (1.5%)	P value
Total protein	5.54^{d}	5.36^{b}	5.19^{a}	5.48^{a}	0.00
Albumin	3.24^{a}	3.64^{c}	3.71^{d}	3.50^{b}	0.00
Creatinine	1.27^{b}	1.04^{a}	1.93^{c}	1.17^{ab}	0.00
Glucose	72.00^{a}	99.00^{c}	81.00^{b}	81.33^{b}	0.00
Cholesterol	195.00^{d}	99.17^{b}	105.67^{c}	90.43^{a}	0.00
Urea	42.05^{d}	30.23^{c}	18.83^{a}	26.00^{b}	0.00
AST	50.27^{c}	22.00^{a}	55.00^{d}	35.00^{b}	0.00
ALT	50.32^{c}	28.87^{a}	62.33^{d}	32.33^{b}	0.00
ALP	128.30^{a}	156.47^{b}	225.43^{d}	201.00^{c}	0.00

a,b,c,d Means on the same row bearing different superscripts are significantly different ($P < 0.05$)

Total protein, Albumin, creatinine, glucose, cholesterol, urea, AST, ALT, ALP showed significant differences ($p<0.05$) among treatment means for serum indices of 8 weeks old broiler birds. Cholesterol of T1 control group was significantly higher ($p<0.05$) than the values of those in the treatment groups fed diets containing mixture of cinnamon, and red pepper. The findings of the current study showed that increasing dosages of cinnamon and red pepper decreased the levels of cholesterol. The activities of aspartate aminotransferase (AST), alkaline phosphatase (ALP), and alanine aminotransferase (ALT) in the blood are bioindicators of liver damage and function (Yildirim *et al.,* 2011). Increased quantities of these enzymes are associated with liver or muscle damage, resulting from the body reactions to stress. The reduction in AST and ALT due to cinnamon and red pepper treatments can be deduced as an indication of better liver function. Reduced activity of ALP may be an indication of a slowdown of bone growth (Szabo *et al*., 2005). Higher serum levels of alkaline phosphatase are observed when there is improved osteoblastic activity, involving the formation and mineralization of bone associated with increased skeletal growth (Lumeij *et al.,* 2008). Also, the values of ALP in the present study are in agreement with the referenced values of 167ul – 305ul for poultry birds (Oleforuh-Okoleh *et al.,* 2015). Creatinine of T3 fed diet containing 1.0% inclusion level of cinnamon and red pepper showed higher value than the other dietary group and it also shows that T4 was statistically similar to T1 and T2. These findings indicated that mixture of cinnamon and red pepper had no harmful effects on kidney function. Various studies using phytobiotics supplementation in broiler chickens supports this results, including the work by Rubio *et al*, (2019), Ahmad *et al*.,(2018), and Adegoke *et al*.,(2018). Glucose value of T2 fed diet containing 0.5% level of cinnamon and red pepper mixture was significantly higher ($p<0.05$) than the values of other treatment group. The normal reference range of serum glucose in broiler is 200 to 500 mg/dL (Thrall *et al*., 2012). The present study showed that the serum glucose concentrations were influenced by cinnamon and red pepper in the experimental chickens; however, low values were recorded in the control group compared to treatment groups. Total protein of T1 was higher than the ones in the treatment group containing cinnamon and red pepper mixture. Albumin of T3 fed diets containing 1.0 inclusion levels of cinnamon, and red pepper mixture showed higher value than the ones in the other group. The quantity of serum protein in birds is considered an important indicator for the determination of their health status. The results showed that the inclusion of cinnamon and red pepper significantly increased the levels of albumin compared to the control group but the total protein decreased among treatment group and increased in the control group. In addition, albumin showed linear increases with increasing supplementation of cinnamon and red pepper mixture at 1.5%.

CONCLUSION

The research results showed that incorporating cinnamon and red pepper mixture at 0.5 % in broiler diets improved the serum and haematological indices which led to better health.

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Comparative Toxicity Of *Zingiber officinale* and Deltamethrin On *Prostephanus Truncatus* (HORN)

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K E Y W O R D S

Cassava chips,
Deltamethrin,
Insect Mortality
Prostephanus truncatus,
Zingiber officinale,

A B S T R A C T

In Africa, Prostephanus truncatus is a destructive pest of economic importance which has deteriorative effects on dry cassava chips in storage. The present study investigates the effects of Zingiber officinale on P. truncatus on dried cassava chips . Deltamethrin was used as the reference insecticide. The plant extract was used at different concentrations (500 µg/ml ul/ml, 250ul/ml, 125ul/ml, 62.5ul/ml, 0ul/ml(control) and 0.05ul/ml(reference)) 100g of cassava chips were put in a plastic plate and treated differently with Z. officinale and Deltamethrin, the control contains only acetone, each treatment was replicated 3times .10 unsexed P. truncatus adults were put into each plate and the plates were covered with muslin cloth held with a rubber band. Results were taken after 24hrs, 48hrs, 72hrs and 7days after treatment. All the data generated was subjected to one-way analysis of variance (ANOVA) No reference in abstract. The result of the experiment showed that Z. officinale recorded one hundred percent mortality at higher concentrations of 250ul/ml and 500ul/ml,and for which time duration? its effects were similar to the reference insecticide.

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INTRODUCTION

Cassava (*Manihot esculentus*) is a staple food crop in Africa, produced in large quantity by peasant and commercial farmers with Nigeria being the highest producer in the world .(FAO, 2013). In order to prevent its deterioration and wastage, fresh roots of cassava are converted into dried chips. The process of conversion into chips, is achieved by drying and subsequent storage for long periods until needed. However during this storage period, dried cassava chips are exposed to attack by insect pests, thus threatening food security in sub-Saharan Africa. Parker and Booth. (1979) reported that cassava chips are heavily infested during sun drying and when in store by a number of stored product pests including the larger grain borer P. truncatus (GASGA ,1993).

The Larger Grain Borer (LGB) ,*Prostephanus truncatus* (Horn) (Coleoptera : Bostrichidae), is a stored product pest beetle indigenous to Central America , where it has spread to many countries (Eppo, 2013) . In Africa, it was accidentally introduced through Tabora region of Tanzania in the late 1970s the capacity to exploit a new environment (Dick, Ress, Lay and Ofusu 1989). This pest has become a serious pest of stored maize and dried cassava in part of east, South and West Africa (Eppo, 2013). In, Southwestern part of Nigeria, the earliest reports of *P. truncatus* indicated its presence in areas of Oyo, Ogun and Lagos States, mostly in areas near the border with the Republic of Benin (Pike, Akinnibagbe and Bosque-Peres 1992) . However, Echendu and Ojo (1997) reported that *P. truncatus* has moved out of the border areas of the south-west from where it probably entered into the country but extent of spread is yet unknown. According to Espinal , Markham and Wright *(*1996), adult and larval stages of *P. truncatus* has ability to damage wide range of commodities including some roots and tubers, cereals, pulses, cocoa, coffee, groundnut and wooden structures.Objectives of the study.

MATERIALS AND METHODS

Study Area

The study was carried out in the Department of Parasitology and Entomology, at the Science Village of the Faculty of Bioscience Nnamdi Azikiwe University Awka (6°14'N ,6°14.5'N to 7°8, 6°E, 7°9'E) Anambra State (6°25'N, 7°12'E) The annual rainfall of the area ranges from 1,000mm - 1,500mm with 2 seasons – dry and rainy.

Experimental Design

The 4 experiments were laid out in 5x2x2(concentration, insecticides, varieties and processing methods) Factorial experiment in Completely Randomized Design (CRD) with each treatment repeated 3 times.

Experimental Insect Collection and Culture

The adult larger grain borer, *P.truncatus* that was used for the study was obtained from commercial produce stores in Eke Awka market. One kilogram (1kg) of the dried cassava chips containing both lavae and adult was weighed into a transparent 2kg bucket. Prior to the culturing. One kg of the dried cassava in a sealed polythene bag was refrigerated for 3 days at 4^{o}C to kill any hidden infestation. Thereafter, it was infested with the pest. The Culturing lasted for a period of 40 days under ambient laboratory temperature and humidity conditions. The newly emerged F1 adults were used for the experiment.

Source and Extraction of *Z.Officinale*

Z.officinale rhizome was sourced from Eke Awka market. Two kg each of these plant products were peeled, sliced, and dried under shade for 12days at 65^{o}C, it was thereafter pulverized. The crude extracts were extracted using n-hexane in Soxhlet apparatus. The n-hexane was removed with rotary evaporator.The extraction was carried out in Botany laboratory in the Department of Botany, Nnamdi Azikiwe University, Awka

Source of Deltamethrin

Deltamethrin 12.5 EC equivalent of 15.5g/l of active ingredient was sourced from Comfort Agro Chemical Nigeria Limited Onitsha, Anambra State,

Serial Dilution of Z. *Officinale*

The serial dilution of the crude extract was prepared in acetone using 20ml syringe to obtain 50%, 25%, 12.5% and 6.25% thus obtaining 500 ul/ml, 250 ul/ml, 125 ul/ml and 62.5 ul/ml of oil per 1 ml respectively.

Residual Effect of the Oil Extract of Zingiber Officinale and Deltamethrin

Sterilized different processed forms of cassava chips weighing100 g were put into plastic plates and treated with 2 mls of the oil extracts (500 ul/ml, 250 ul/ml, 125 ul/ml and 62.5 ul/ml), deltamethrin was applied at 0.005ul/ml. The applications were done with the aid of a syringe and mixed thoroughly. Deltamethrin was used as a reference insecticide while acetone was used as the control. The chips were air dried for one hr to enable the acetone to vapourize and a cohort of 10 *P.truncatus* of 15days old were introduced into the treated cassava chips. The plates were covered with a muslin cloth and held with a rubber-band to aid ventilation and prevent the escape of the insects. Each treatment was replicated 3 times and the set up were kept under the laboratory conditions of 25-34^{o}C and 61-92% RH. Mortalities were recorded at 24hrs, 48hrs, 72hrs and 7th day

Data Analysis

The data collected on insect mortality, damage and loss was subjected to one-way analysis of variance (ANOVA) in Genstat package 9.2 (9th edition). Difference between mean values were separated using least significant difference (LSD) at P<0.05 (Finney 1971).

RESULTS AND DISCUSSION

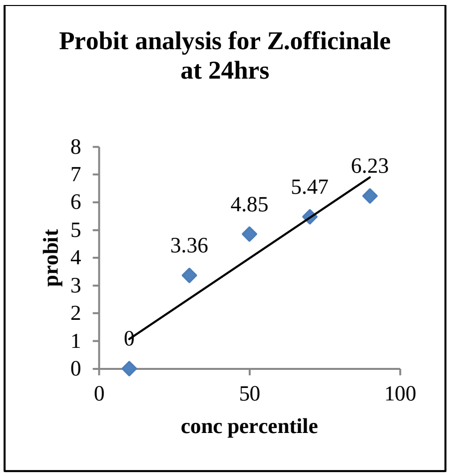
Evaluation of *Z. officinale* on mortality (24, 48, 72hours and 7 days after treatment)

The effect of concentration, on percentage mortality of *P. truncatus* at 24, 48, 72 hours and 7 days after treatment (DAT) with *Z. officinale* is presented in Table 4.1.1a. The result obtained showed that the concentration levels were significant ($P < 0.05$) at 24, 48, 72 hours and 7 DAT.

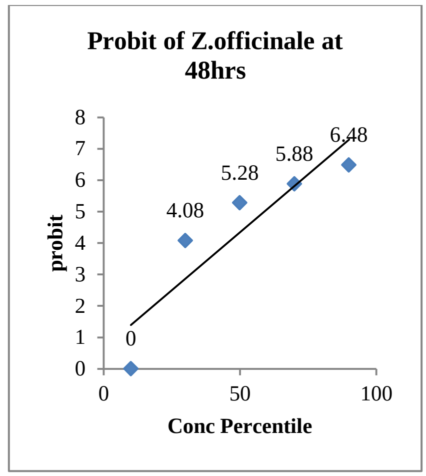
Table 1: Main effect of Concentration, on percentage mortality at 24, 48, 72 hours and 7 Days After Treatment (DAT) with *Z. officinale*

	Mortality			
Concentration (ul/ml)	24hrs	48hrs	72hrs	7DAT
Z. officinale (500)	89.17	93.33	99.17	100.00
Z. officinale (250)	67.50	80.80	92.50	100.00
Z. officinale (125)	44.17	60.83	75.83	99.22
Z. officinale (62.5)	5.00	17.50	23.33	65.00
Z. officinale (0)	0.00	0.00	0.00	0.00
Deltamethrin (0.005)	99.17	100.00	100.00	100.00
LSD (0.05)	6.048	5.200	4.675	4.303

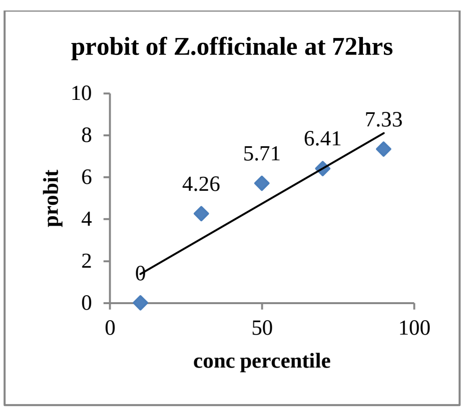
Probit analysis of *Z.officinale* at 24hrs, 28hrs, 72hrs and 7 days after treatment



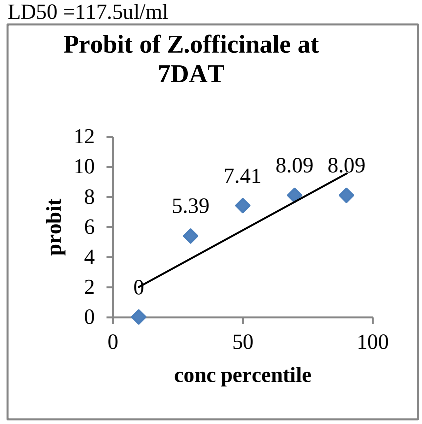
Y = ax + b
Y = 2.30x + (-0.15)
5 = 2.30x – 0.15
X = 2.239
LD50 = antilog x
LD50 = 173.4ul/ml



Y=ax+b
Y= 2.43x + (-0.032)
5 = 2.43x - 0.032
X = 2.07
LD50 = antilog x
LD50 =117.5ul/ml



y=ax+b
y = 2.70x + (-0.12)
5 = 2.70x - 0.12
x=1.896
LD50 = antilog x
LD50 = 78.7ul/ml



y=ax+b
y = 3.19x + 0.06
5 = 3.19x + 0.06
x =1.55
LD50 = antilog x
LD50 = 35.5ul/ml

DISCUSSION

In mortality assessment for *Zingiber officinale*, at 24 to 72 hours there was a significant difference ($P < 0.05$) in the concentrations. At 500ul/ml, there was 89% mortality recorded at 24hrs, which was significantly lesser than the mortality recorded in the reference which was 99%. An increased mortality was recorded in the subsequent days, which implies some of the insects responded quicker to the pesticide than others At 250ul/ml, the mortality recorded at 24hrs was 67.50% which was significantly lesser than the mortality at 500ul/ml. An increased mortality was recorded in the subsequent days. At 125ul/ml, 44% mortality was recorded after 24hrs, which is highly significantly lesser than the mortality recorded at 250ul/ml. At 62.5ul/ml, 5% mortality was recorded after 24hrs, even though there was an increased mortality in the subsequent days, this concentration will not guarantee maximum protection to cassava chips against *P. truncatus*.

On the 7th day, 125 ul/ml, 250 ul/ml and 500 ul/ml gave 100% mortality as the reference insecticide. Ogbonna *et al.* (2014), recorded similar result, according to them no survival (0%) was recorded at 700 ul/ml and 350 ul/ml after 7days of treatment.

The probit analysis which determined the LD50 (lethal dose that will eliminate 50% of the insect) shows that *Z. officinale* has a high level of toxicity. At 24hrs the LD50 recorded was 173.4ul/ml, which means that 173ul/ml of the pesticide eliminated 50% of the insect population after 24hrs. At 48hrs the LD50 recorded was 117.5ul/ml, which means that 117.5ul/ml of the pesticide eliminated 50% of the insect population after 48hrs. At 72hrs the LD50 recorded was 78.7ul/ml. which implies that 78.7ul/ml of the pesticide eliminated 50% of the insect population after 72hrs. On the 7th day the LD50 recorded was 35.5ul/ml. which means that 35.5ul/ml of the pesticide eliminated 50% of the insect population after 7days

CONCLUSION

Z. officinale was effective as the reference insecticide at higher concentration (500 ul/ml). If the concentration of *Z. officinale* used was higher than 500 ul/ml, it may have achieved same result as the reference. Using *Z. officinale* at a concentration below 500ul/ml will not proffer maximum protection to cassava chips in storage against *P. truncatus*

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SUB-THEME 8

ISSUES OF GENDER IN AGRICULTURE, NATURE CONSERVATION AND CLIMATE CHANGE RESPONSE

Gender and Climate Smart Agriculture in Rice Farming in Ikwo Local Government Area, Ebonyi State, Nigeria

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K E Y W O R D S

Gender;
Adoption;
Climate Smart Agriculture;
Rice Farming

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A B S T R A C T

The paper conducted gender analysis of adoption of climate smart agriculture (CSA) in rice farming in Ikwo Local Government Area, Ebonyi State, Nigeria. Cross sectional data from 120 rice farmers (60 male and 60 female rice farmers) were collected. Data collected were analyzed using descriptive statistics. The results showed that the male rice farmers had more access to improved seedlings, and tractor/machinery relative to the female rice farmers. The male rice farmers performed more roles in terms of nursery practices, fertilizer and pesticide applications, while the female rice farmers did more of rice planting, weeding, harvesting, threshing and parboiling. Male rice farmers adopted more of knowledge smart practices, information smart practices, nutrient smart practices, and water smart practices, than female farmers. The study recommends farmers to plan their yearly rice cultivation in line with accessed climate change information and effectively adopt CSA practices and techniques to avert adverse climate changes in the state.

INTRODUCTION

Extreme climate events, such as heavy precipitation, on-going flooding, and rising temperatures, have all had a significant negative economic impact on rice agriculture. Rice production contributes to greenhouse gas emissions globally (FAO, 2021; Durodola, 2019). Flooded paddy rice field is a major contributor of global methane emissions. Burning rice leftovers like straw and husks also contributes to the release of greenhouse gases (Niveta and Pathak, 2013 and Pires *et al.,* 2015). Previous studies have demonstrated that the global output of rice is being negatively impacted by climate change. The great majority of climate change's negative effects on rice production are mostly caused by changes in temperature and precipitation, which cause flooding, a shortage of freshwater, and an increase in pests, diseases, and weeds (Phanith and Malyne, 2012; Md. Abdur *et al.,* 2014; Omchand, 2019). Rainfall usually has a negative effect on rice plants during the early and flowering stages of the reproductive phase, which results in significant reductions in rice production (Abbas and Mayo, 2021). Increased water loss, yellowed and wilted leaves, slowed root development, and even seedling death are all effects of high temperatures (Zeng *et al.,* 2017, Ogah and Nwilene, 2017; Saliu *et al.,* 2019).

Studies have shown that women farmers are mostly vulnerable to climate change unlike the men farmers, women suffer adverse climatic effects due to societal, and cultural (customs and traditions) that denies them access to climate information and adoption technologies. Their inabilities to freely access climate information coupled with restricted access to climate change seminars, meetings, gatherings, conferences, etc endangers them to adverse climatic consequences (Rao *et al*., 2019; Duru *et al*., 2022). In addition, their feminine and domesticated roles and responsibilities as wives and mothers occupy their time and thus expose them to climate change. On the other hand, male farmers enjoys all the societal and cultural privileges regarding to access to climate change information, their ability to access early climate change signals and attend meetings, seminars, relating to climate change leverage them from unseemly climate change disturbances (Rao *et al*., 2019). Considering the devastating impacts of climate change on rice production, there is urgent need for adoption of climate smart agriculture (CSA) to increase rice production in the state. CSA is broadly projected to lessen the devastating effects of climate change on the agriculture sector (Onyeneke *et al.,* 2021). CSA includes a set of practices and innovations that improve adaptive tendencies and resilience of rice farmers in adapting to climate change inconsistencies while further developing food and nutrition security and relieving carbon emissions and other greenhouse gases (World Bank, 2016). CSA offers household farmers the opportunity to leverage on adverse climatic effects and untold weather and atmospheric conditions. Most generally distinguished CSA practices incorporate information smart practices, knowledge smart practices/administrations, water smart advances, nutrient smart practices and weather smart practices/administrations (FAO, 2022). Other sub-practices incorporates changing crop types, modifying planting dates, adoption of tolerant crop varieties, crop expansion and diversifications, mechanical land levelling, use of agro-automated tilling machines and other agronomic practices such as (cover cropping, crop rotation, and minimum tillage, etc) (Mishra *et al*., 2021).

However adoption of CSA differs between men and women farmers, men are usually broad in adopting CSA unlike the women farmers. They are ever readily and eager to adopt any tested and proven CSA being introduced to them without any forms of reservation or misbelieve (Jost *et al*., 2016). Being culturally and resource favoured they are always on the frontline to expand their land cultivations for increased yields and production and thus seeks to adopt sustainable CSA made available to them. The women farmers due to their nature and cultural restrictions and resource limitations are usually narrow and objective in adopting CSA. Prior now, no studies had explored the gender analysis of adoption of CSA in rice farming in Ebonyi State Nigeria, hence this created the gap in knowledge and the motivation of the study.

METHODOLOGY

The study was done in Ikwo Local Government Area (LGA) in Ebonyi State, Nigeria. Farming is the major occupation of the people of the area. The population of the study was male and female rice farmers. Four communities were selected from the LGA. In each community, twenty rice farmers (ten male rice farmers and ten female rice farmers) were selected. A total of one hundred and twenty (120) rice farmers (60 female and 60 male rice farmers) were interviewed for this study. Primary data were collected from the respondents using a structured questionnaire on information relevant to this study. Descriptive statistics was used to analyze the data collected.

Results and Discussion

Gender difference in access to resources, roles performed and decision making processes

Table 1 showed the gender difference in access to resources, roles performed and decision making processes of the rice farmers. Male farmers (95%) have more access to improved seed than the female farmers (83%). This could be premised on the engagement of more male farmers than female farmers on rice farming operations. The high percentage accessibility could also result from the rigorous hurdles encountered in accessing improved seedlings which favours the male farmers relative to the female farmers (Lateef *et al*., 2021; Namonje-Kapembwa and Chapoto, 2016). The tractor/machinery showed that male rice farmers (53%) had more access to tractor/machinery in comparison to the female rice farmers (38%). This is possible because of the cost implications of such tractors/machineries which the female farmers may not be able to afford due to their poor financial constraints and limitations (Paris *et al.* 2015).

The nursery operations showed that the male rice farmers (83%) performed more nursery roles relative to the female farmers (28%). This could be due to their desire to shield young rice seedlings from unwanted external factors mostly climate change before transplanting to the permanent field for proper growth and yields (Kinkingninhoun *et al.,* 2020). Female rice farmers (97%) were more involved in rice planting than the male rice farmers (48%). This could result from their intensive engagements in rice cultivation and production. Applications of pesticides indicate that male rice farmers (87%) had more access to agrochemicals than their female counterparts (78%).

Similarly, over 90% of the female rice farmers also performed threshing and parboiling roles than the male rice farmers. This could be attributed to their doggedness and effectiveness in rice farming which is widely acknowledged (USAID, 2022). Land to be cultivated and seed/seedlings to be planted indicate that the male rice farmers took firm and unwavering decisions in these operations more than the female rice farmers (Kamal *et al.,* 2021). Male rice farmers made tangible decisions on labour allocations and use of agrochemicals relative to the female farmers. This could be due to their manly dispositions accorded by society and nature in taking vital and cogent decisions at all times (Aigbokie *et al.,* 2021). Male rice farmers took more decisions on capital to be acquired/borrowed, sales of farm produce and purchase relative to the female farmers.

Table 1: Distribution of male and female rice farmers by access to resources, roles and decision-making in rice production

	Gender	Frequency	Percentage
Access to resources			
Land	Male	56	93.00
	Female	51	85.00
Credit	Male	27	45.00
	Female	24	40.00
Grants	Male	11	18.00
	Female	9	15.00
Improved seeds	Male	57	95.00
	Female	50	83.00
Fertilizer	Male	59	98.00
	Female	59	98.00
Climate information	Male	34	57.00
	Female	37	62.00
Training/skills	Male	29	48.00
	Female	29	48.00
Pesticide	Male	52	87.00
	Female	47	78.00
Tractor/Machinery	Male	32	53.00
	Female	23	38.00
Roles performed			
Nursery	Male	50	83.00
	Female	17	28.00
Rice planting	Male	29	48.00
	Female	58	97.00
Applying fertilizer	Male	53	88.00
	Female	27	45.00
Applying pesticides	Male	51	85.00
	Female	10	17.00
Weeding	Male	12	20.00
	Female	47	78.00
Harvesting	Male	33	55.00
	Female	56	93.00
Threshing	Male	12	20.00
	Female	49	82.00
Parboiling	Male	27	45.00
	Female	55	92.00
Decision making			
Land to be cultivated	Male	53	88.00
	Female	25	42.00
Seeds/seedlings to be planted	Male	55	92.00
	Female	32	53.00
Labour allocation	Male	59	98.00
	Female	35	58.00
Agrochemicals to be used	Male	54	90.00
	Female	27	45.00
Capital to be acquired/borrowed	Male	53	88.00
	Female	26	43.00
Sale of farm products	Male	51	85.00
	Female	28	47.00
Purchase decisions	Male	54	90.00
	Female	28	48.00

Gender difference in adoption of climate smart agriculture in rice production

Table 2 showed the gender difference in adoption of climate smart agriculture in rice production. The results revealed that nursery operation was an important knowledge smart practice engaged by both male and female rice farmers. Female rice farmers adopted the practice more than the male farmers. Male rice farmers practiced more of intercropping and minimum tillage than their female counterparts in the area. This is done to maximize the available farmlands and to equally harvest other crop produce outside rice production (FAO, 2015). Shifting cultivation and knowledge of integrated pest management were also adopted by male and female rice farmers. However, male rice farmers adopted more of shifting cultivation and integrated pest management than their female counterparts. Information on good quality agrochemicals and application was an important practice with percentage adoption value of 88% for male farmers and 58% for female farmers. This implies that male rice farmers embraced quality information on agrochemicals and its applications more than the female rice farmers. Adjusting planting dates was also an important practice with percentage adoption value of 82% for male farmers and 66% for female farmers implying that the male rice farmers adjusted their planting dates more than the female farmers (Antwi-Agyei *et al.,* 2021). Water smart technologies such as sprinkler irrigation and drainage were significant climate-smart practices engaged by the male and female rice farmers.

However, over 90% of the male rice farmers engaged more in the use of these water smart technologies relative to their female counterparts. This could be premised to ensure all round water availability and drainage provisions for proper and adequate rice farming. Nutrient smart practices had mulching, organic and inorganic fertilizer use, green manure, cover cropping and agro-forestry as climate-smart practices. Male rice farmers adopted and utilised more of green manure, cover cropping and agro-forestry than the female rice farmers while the female farmers adopted mulching, organic and inorganic fertilizer more than their male counterparts.

Table 2a. Distribution of male and female rice farmers according to adoption of climate smart agricultural practices

Climate smart agricultural practices/technologies/services	Gender	Frequency	Percentage
Knowledge smart practices			
Nursery	Male	30	50.00
	Female	44	73.00
Intercropping	Male	42	70.00
	Female	28	47.00
Minimum tillage	Male	38	63.00
	Female	24	40.00
Crop Diversification	Male	46	77.00
	Female	42	70.00
Shifting Cultivation	Male	43	72.00
	Female	32	53.00
Knowledge of integrated pest management	Male	49	82.00
	Female	37	62.00
Improved rice varieties	Male	52	87.00
	Female	53	88.00
Mixed farming practice	Male	49	82.00
	Female	50	83.00
Livelihood diversification	Male	54	90.00
	Female	44	88.00
Information smart practices/services			
Information on good quality agrochemicals and application	Male	53	88.00
	Female	35	58.00
Information on where to buy improved varieties	Male	59	98.00
	Female	49	82.00
Information on availability of grants	Male	8	13.00
	Female	8	13.00
Information on other rice farming technologies	Male	27	45.00
	Female	19	31.00
Adjusting planting dates	Male	49	82.00
	Female	40	66.00
Adjusting harvesting dates	Male	47	78.00
	Female	39	65.00
Water smart technologies			
Normal irrigation	Male	22	37.00
	Female	18	30.00
Drip irrigation	Male	9	15.00
	Female	7	12.00
Sprinkler irrigation	Male	26	44.00
	Female	17	28.00
Drainage	Male	53	88.00
	Female	31	52.00

Table 2b. Distribution of male and female rice farmers according to adoption of climate smart agricultural practices

Climate smart agricultural practices/technologies/services	Gender	Frequency	Percentage
Nutrient smart practices			
Organic manure	Male	16	27.00
	Female	17	28.00
Green manure	Male	44	73.00
	Female	29	48.00
Fertilizer	Male	58	97.00
	Female	60	100.00
Mulching	Male	21	35.00
	Female	26	43.00
Cover cropping	Male	49	82.00
	Female	31	52.00
Agroforestry	Male	44	73.00
	Female	28	47.00
Weather smart practices/services			
Insurance	Male	10	17.00
	Female	6	10.00
Climate information service	Male	34	57.00
	Female	35	58.00

CONCLUSIONS

Climate change has become a topical issue and concern of rice farmers in Ebonyi State due to its negative influences in rice cultivation and production. Results showed that the male rice farmers had more access to improved seedlings, and tractor/machinery. Again the male rice farmers performed more roles in terms of nursery practices, fertilizer and pesticide applications while the female rice farmers did more of rice planting, weeding, harvesting, threshing and parboiling. The male farmers made firm decisions on lands to be cultivated, seeds to be planted, labour allocations, agrochemicals, and capitals. Again, the male rice farmers adopted more of knowledge, information, water, and nutrient smart practices, while the female rice farmers adopted more of weather smart practices. The study recommends farmers to plan their yearly rice cultivation in line with accessed climate change information and effectively adopt CSA practices and techniques to avert adverse climatic change.

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Strengthening Fisheries and Aquaculture through Climate-Smart and Gender-Sensitive Approaches in Nigeria

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K E Y W O R D S

Aquaculture,
Climate-smart,
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A B S T R A C T

Climate change is a reality that is experienced in different parts of the world. For this reason, a review was conducted to understand how fisheries and aquaculture can be promoted using climate-resilient and gender-inclusive measures. Nigerian fisheries and aquaculture sub-sector has high potential for development but is already experiencing climate change impacts like flooding and extreme droughts. The sector needs to play its role in contributing to the food, nutrition and livelihood security of the people of Nigeria. Developing climate-smart approaches with a gender-balanced perspective is key to ensuring success in mitigation of its effects. For this to be possible, the challenges limiting the growth of the sector must be addressed by the policy makers, researchers, and other stakeholders. Women need to be given the right space to play their roles in the fisheries and aquaculture sector just like the men. This will require some institutional framework and support on the part of the government to be achieved. If these are done fisheries and aquaculture will achieve the desired growth envisaged in the Code of Conduct for Responsible Fisheries and National Aquaculture Strategy.

INTRODUCTION

The fisheries and aquaculture sector is a very important component of the food production systems in every society striving towards achieving the UN Sustainable Development Goal on food security. This article is significant to the achievement of six goals within the Sustainable Development Goals (SDGs).The time is tickling based on the fact that 2030 is very close and there is the need to speed up with the actions that will lead to the achievement of the goals.

Therefore, programs and initiatives geared towards ecosystem restoration and food security have the imperative of inclusion of some aspects of fisheries and (or) aquaculture to be holistic and cost-effective. Under circular economy, the sector is very useful in the transformation of some agricultural and food processing wastes into useful resources for further food production while its own waste becomes useful in agriculture (Bosma and Verdegem, 2011; Dawood *et al*., 2018). Some of them can easily be cultured on wastes from different human domestic and industrial activities, especially food-processing wastes.

The term fisheries connote fish (or shellfish) and all activities associated with managing it and making it available for human consumption. This essentially refers to fishes in the wild or what is alternatively called capture fisheries. The capture fisheries sector focuses on harvesting, landing, storage and (or) processing and the logistics that ensure the fish reaches the consumers. Aquaculture on the other hand refers to the farming or husbandry of aquatic organisms: fish, shellfish, plants, etc. (Pandey and Shukla, 2005)

Fish provides not only proteins of high value but are source to a wide range of essential micronutrient minerals, vitamins and essential fatty acids (Highly Unsaturated Fatty Acids-HUFAs) very essential for human health (FAO, 2012). Fish is readily digestible and utilizable by human body, making it suitable for complimenting the high carbohydrate diets in most in most developing countries (FAO, 2008). Fish have all the essential amino acids required by the body. On the average, it provides 20-30 kilocalorie per person per day (WHO, 2011). The fisheries sector contributes 3-4.5% of the gross domestic product (GDP) in Nigeria and constitutes 50% of animal protein consumption (Federal Ministry of Agriculture and Rural Development [FMARD], 2008: Onada and Ogunlola, 2016). Fish consumption per caput is 7.5kg in Nigeria (FMARD, 2008) while the global average is 20.2kg (FAO, 2022). Nigeria spends approximately one billion dollars annually in the importation of a million metric tons of fish to augment the local production deficits (Obasi *et al*., 2017). The fisheries and aquaculture sub-sector employed one million one hundred and ninety thousand persons as at 2016, with women and youths involving more in the postharvest value chains (Subasinghe *et al.,* 2021)

Climate-smart fisheries and aquaculture techniques are those production techniques that result in minimal harm to the ecosystem thereby ensuring the sustainability, diversity and resilience of the system without undermining the socioeconomic system. It is an adaptation to climate change and should result in lower emission intensities per output (Onada and Ogunlola, 2016).

Gender-sensitive approach implies measures or practices that will ensure that there is a balance of both male and female genders in the fisheries and aquaculture sub-sector. This becomes necessary given earlier reports indicating that different parts of both the fisheries and aquaculture value chain are being dominated by the male gender (Giwa *et al*, 2017; Unah *et al.*, 2017; Subasinghe *et al.,* 2021).

Climate change is the alteration of the pattern of the climate of a place over a given period of time: usually ten years and above. Recent weather events like changes in hydrological regime, drastic change in weather condition, reduction water levels, heavy windstorms, excessive sunshine, increased incidences of flooding and drought are being linked to climate change (Onada and Ogunlola, 2016). This review is thus aimed at exposing the adaptation strategies needed to cushion the negative effects of climate change. This will be covering those needed for fisheries and aquaculture as well as issues of gender inclusivity.

Climate-Smart Fisheries Approach

Federal Department of Fisheries (FDF, 2021) noted that climate change will affect fisheries strongly given that it will have impact on fishes on which fisheries depend. It is envisaged that artisanal fisheries which currently accounts for 85% of local production (Obasi *et al*., 2017) will be affected through multiple weather events like windstorms, rising sea levels, warming that lead to migration and (or) extinction of some economic species (Evulobi, 2015) near the coast which may impede the capacities of the communities to operate. Warming is also expected to lead to more stratification of inland lakes leading to anoxic hypolimnion and ultimate fish kills (FDF, 2021). Already, reports on Nigerian coastal waters indicated that some of the economic species of fish: croakers, soles, catfish and groupers are overfished and that revenue of the fishermen have been dwindling due partly to unregulated industrial fishing in the inshore waters against the law. This is in addition to the challenge of unlicensed foreign fleets operating illegally in Nigeria’s territorial waters and landing our fishes at foreign ports for importation back to Nigeria (Jim-Saki *et al*., 2017; Obasi *et al*., 2017). Already, the Nigerian fisherfolks are grappling with lack of institutional support, good roads, storage and processing facilities and poor logistic infrastructure that has limited distribution of many commercial species to the south (Unah *et al.,* 2017; Subasinghe *et al*., 2021). These challenges are expected to be exacerbated by the impact of climate change; but can be addressed if some climate-smart measures are taken.

Climate-smart approach to fisheries is based on the Ecosystem Approaches to Fisheries (EAF) which is derived from the Code of Conduct for Responsible Fisheries (CCRF). It outlines the following principles in relation to the ecosystem:

1. ‘Management measures should not only ensure the conservation of target species but also species belonging to the same ecosystem.
2. States should facilitate consultation and effective participation of all stakeholders.
3. All critical habitats such as wetlands, mangroves, reefs, lagoons, nursery and spawning areas should be protected and rehabilitated.
4. States should ensure that fishery interests are taken into account in the multiple uses of coastal zones and are integrated into coastal area management.
5. States should promote responsible development of aquaculture including evaluation of the effects on genetic diversity and ecosystem integrity.
6. States should establish effective procedures to undertake appropriate environmental assessment and monitoring with the aim of minimizing adverse ecological changes and related economic and social consequences’ (Staples and Funge-Smith, 2009).

Climate-smart fisheries will then involve using harvesting techniques that are safe to the environment, use of gears that exclude non-target species and sizes to minimize bycatch, fishing populations at rates less than or within the established maximum sustainable yields. It will also entail adopting transportation means with the least climate impact in delivery of the landed fish. Similarly, storage and processing facilities ought to deploy the best procedures and technologies that promote minimal emission of greenhouse gases like the carbon II oxide, carbon IV oxide and chlorofourocarbon (CFC) coolants.

In this regard, trawling, use of sea rakes, use obnoxious chemicals in fishing and other related destructive fishing techniques are discouraged. Operators of fishing fleets are to use nets of appropriate mesh sizes. Governments are expected to develop plans of action for reducing bycatch, incidental catch of seabirds, conservation and management of sharks, management of fishing capacity, stop all forms of illegal, unreported and unregulated fishing (Staples and Funge-Smith, 2009). Processing technologies that use charcoal or firewood are, also, discouraged because they lead to deforestation.

Climate-Smart Aquaculture

Aquaculture in Nigeria is still in its early stages of development with a contribution of only six percent to the local fish production (Obasi *et al*., 2017) and only two groups of fish, catfish and tilapia, being cultured in the output ratio of 6.5:1 respectively; and most of the farms located mainly in the southwest (Subasinghe *et al*., 2021). Given this backdrop, it is imperative that its development be conducted in accordance with the CCRF to ensure sustainability and climate-resilience.

The CCRF principles relating to aquaculture says that:

1. States should produce and regularly update aquaculture development strategies and plans to ensure that aquaculture development is ecologically sustainable and to allow rational use of resources shared by aquaculture and other users.

2. States should ensure that the livelihoods of communities and their access to fishing grounds are not negatively affected by aquaculture developments.

Estimated potential of aquaculture production per annum in Nigeria is 2.5 million metric tons (FMARD, 2008) but it currently accounts for a local annual production of 6% of the approximately one million metric tons from the fisheries and aquaculture sector, whereas local fish demand stands at two to three million two hundred thousand metric tons (Obasi *et al*., 2017; Chukwunonye and Amaechina, 2022). Aquaculture, although currently low, can serve as a strong livelihood enhancement sector and can also play key role in food security if well developed. Given that the capture fisheries is dwindling (FMARD, 2008; Obasi *et al*., 2017), it remains an important path to achieving the sustainable development goals earlier mentioned. It is commendable that some states like Delta, Lagos, Oyo, Rivers and Ogun have value chain clusters in the fish farm villages and/or large concentrations of farms either established by the government or through private and public partnerships. Aquaculture remains the among the fastest growing food sub-sector with a growth of 4.6% between 2010 and 2020 (FAO, 2022). Some of the challenges with aquaculture production which are also opportunities for investments are: availability and accessibility to better farming practices, availability of inputs: quality fish seed and feed. Accessibility of finance is also a limiting factor (Subasinghe *et al*., 2021)

Nigeria has an aquaculture development policy as enshrined in FMARD (2008) which states: 'The Nigerian National Fisheries Policy is to achieve increased domestic fish production from all sources on a sustainable and renewable basis to the level of self-sufficiency and fish export in the medium to long term'. Given the challenges highlighted above, it remains unclear how much is being implemented particularly in recognition of the guidelines given in the CCRF.

As at 2008, Nigeria had about 2600 fish farms producing mainly catfish and tilapia (FMARD, 2008). It is now not very clear how many farmers are being affected by climate change. Certainly, many during the 2012 and 2022 flooding events on the Benue-Niger trough and its tributaries must have lost not just their stocks worth millions of Naira but also their production infrastructure. Same is also the case for the northern part of Nigeria where relatively longer droughts are being experienced. Without enabling environment, the effect of these factors can be more challenging, especially for small-holder farms. Hence the strategies for climate change adaptation should start with an enabling environment created by Government.

Adaptation strategies include: use of tarpaulin or plastic tanks (this last better if protected from extreme solar irradiation) during dry seasons, adjusting stocking time to when the stock can better adapt to climate impacts, erection of shades over ponds to for temperature control, installation of boreholes or digging of wells during dry periods, well designed drainage systems to guard against flooding (Onada and Ogunlola, 2016), planting of trees near pond areas to trap excess nutrients in percolating water, use of probiotics to minimize use of antibiotics, reduction in fishmeal dependence of feed production, improving water efficiency through intensification, improving productivity through enhancement of periphytic community in ponds and aeration (Bosma and Verdegem, 2011; Dawood *et al*., 2018), location of farms far from the floodplains or flood-prone areas, use of solar-powered smoking kilns, electric powered kilns or gas operated kilns rather than charcoal to reduce carbon fingerprint and deforestation. For farms located in zones of relatively cold weathers like Jos and Manbila Plateaus, greenhouses can be constructed for the farm where possible to ensure temperature control.

For farms having tendency of discharging wastes into the environment, it is imperative that wastes are treated in line with extant standards before being discharged to minimize pollution and alteration of environmental quality. For maximal returns to the investor and a reduction of environmental footprints, polyculture, integrated culture and aquaponic systems should be implemented. This is because they are amenable to efficient use of resources and lesser waste generation just like it is with use of floating feeds (Bosma and Verdegem, 2011).

Gender Approach to Fisheries and Aquaculture

Studies have tried to interrogate the issue of gender participation in fisheries and aquaculture. Unah *et al.* (2017) noted that fish distribution channels in Lagos are dominated by the males. The prefarmgate value chain of aquaculture is male dominated with a large proportion of then having tertiary education suggesting that the value chain is knowledge-intensive (Subasinghe *et al*., 2021). A study in Ijebu-Ode, Ogun State showed that the fish farms were male dominated to the tune of 70% (Giwa *et al*., 2017). A study to ascertain the specific activities involving the females showed that they are involved in the area of sorting, processing and sale of processed fish in the artisanal fisheries (Nwezza *et al*., 2017: Subasinghe *et al*., 2021). Ikeobasi and Opara (2017) noted that women's participation in aquaculture is livelihood-driven; and their involvement is in mainly in marketing, processing and routine pond management in descending order of importance, far fewer numbers were involved in breeding, harvesting, feed production and pond construction, probably because of the labour-intensive and (or) technical nature of these activities.

In general, challenges that must be addressed to mitigate lopsided participation of both gender in fisheries and aquaculture are highlighted below. In artisanal fishery, a lot of manual labour is required and this limits women. Also, lack of organized cooperative societies, household chores, education and technical know-how are impediments to women's full participation. In aquaculture, inadequate capital, land and high cost takeoff infrastructure for fish pond establishment, high cost of feed, dominance by spouse, inadequate technical-know, omission of women in planning, implementation and monitoring of conservative initiatives are major problems as well (Ekprikpo and Chidinma, 2021).

Extension workers should be detailed to assist the fisher folks especially women to organize themselves into cooperative societies to be able to take advantage of the numerous benefits from it. The aspect of household chores can be mitigated through proper understanding between spouses and a willingness to complement each other depending on the family priorities.

Institutional Support Needed

There is the need for the regulatory agencies to ensure strict adherence to the CCRF in Nigeria. Practical efforts should be made to ensure that the livelihoods of the artisanal fisher folks are protected. The fishermen should form nationwide associations that will draw public attention to their plights. The Nigerian Navy and the maritime wing of the Nigeria Police should improve on security efforts in the region to guarantee that industrial fishing operates strictly beyond 13 nautical miles as stipulated in the law. Processing technologies with less carbon fingerprints like solar-powered fish drying kiln, electrically operated fish drying oven and gas-powered fish drying kilns should be introduced with government giving accessible incentives for their adoption in processing facilities. Complicit members of the regulatory teams should be fished out and disciplined if necessary to ensure that there will be no breach of Nigeria's territorial waters by foreign fishing fleets. In line with goals of the code, demersal fishing should also be conducted in such a manner as to preserve the ecological integrity of the sea bed. There should be regular coordinated monitoring of our inland fisheries and activities around the various water bodies to ensure that overfishing, pollution and other environmentally degrading practices are minimized.

Government should add incentives that can boost participation in aquaculture through providing basic amenities; particularly, storage and logistic facilities (Unah *et al*., 2017) to ensure the fish reaches the consumer in good condition. Such laudable government programs like the anchor borrowers' program and others can be upscaled to accommodate a reasonable percentage of smallholder aquaculturists. Researchers should conduct reviews to make available to the actors the best practices. Public-Private Partnerships in floating feed mills development can be established to enhance feed efficiency in farms (Subasinghe *et al*., 2021).

Adult education programs should be organized in the fishing communities as this is key to ensuring they have the basic communication skills that will help in their business, special training programs can be targeted at women in fisheries and aquaculture to fill relevant skill gaps. To ensure that women can have access capital to establish farm government can develop special grants to encourage their participation, banks can be given special credit facilities by Central Bank of Nigeria dedicated to ensuring their participations in the preharvest and postharvest value chains. Governments should build more fish farm villages with equal opportunity for access. Concerning issues of spouse dominance, reorientation programs can be conducted through a concerted effort of the Federal Department of Fisheries and National Orientation Agency on the importance of men allowing their wives to freely venture in business. Regular success stories of women in different areas of fisheries should be compiled and used as audiovisuals to encourage men in this regard over time. Government should employ women in different levels of policymaking, implementation and monitoring to enhance inclusivity.

CONCLUSION AND RECOMMENDATION

Fisheries and aquaculture industry are an indispensable part of the food sector ensuring cheaper protein availability for human nutrition, income generation and waste management. The sector can perform optimally if given the enabling environment; it can provide job and food. Responsible fisheries in the face of climate change involves different practices that are geared towards ensuring that the ecological, social and economic systems are sustained. There is the need for fisherfolks enlightenment on the issues of climate smart system and gender inclusiveness for sustainable fisheries and aquaculture value chain diversity. We recommend that the government should create the strong institutional framework needed to drive this change.

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Strengthening Livestock Systems through Climate-Smart and Gender-Sensitive Approaches: An Overview of Nigerian Livestock Production

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ABSTRACT

The livestock industry is an economic enhancer for most countries in the world including Nigeria. Livestock development remains one of the worst hits of climate change resulting to open grazing, low produce and conflicts. This has affected the herders, farmers (especially women farmers), communities and livelihoods. The ability for women to adapt to climate change mostly depend on their ability to access to farm land, credit, security of land tenure, and active participation in decision making regarding land and water resources. Climate change and its effects on livestock production as well as the vulnerable farmers and gender disparity on men's and women's need and priorities in adapting to climate change irrespective CSA initiatives were highlighted. Climate-smart livestock production strategies as well as CSA practices for improving livestock production and the roles of roles of agricultural extension in strengthening livestock systems through climate-smart and gender sensitive approaches were equally emphasized. There is therefore, the need for capacity building of both genders on the strategies to tackle the issues of climate change for enhanced production to achieve sustainable food production. Also, Climate-smart agricultural practices that require specific farm inputs should be made available to livestock farmers. This can be achieved through proper extension service delivery system tailored towards the immediate felt need of the livestock farmers without gender disparity.

INTRODUCTION

Climate change takes the form of unreliable rainfall, prolonged period without rainfall, flooding, extreme variability of increase and decrease in temperature, influences agricultural production all over the world, thus threatens the survival of farmers. Food production in Africa has not significantly increased to meet the food need of the increasing population resulting from climate change and farm and non-farm related challenges (Rosegrant *et al,* 2008). Poor farmers who suffer from marginalization are mostly vulnerable to the serious impacts of climate change reason being that they are highly dependent on climate change prone sectors and has limited human resources, institutional power and financial capabilities to cope with the negativities impacts by climate change (Lambrou and Nelson, 2010). Climate change disproportionately disturbs farming girls and women due to their greater susceptibility to extreme weather-related activities, such as droughts, floods, extreme hot and cold conditions (Woolf *et al*, 2018).

Gender disparities, with reference to climate change effects on agriculture and livestock production, are attributed to social position and roles that women play within families and societies. The ability for women to adapt mostly depend on their ability to access to agricultural land, credit, security of land tenure, and active participation in decision making regarding land and water resources. Most times because of the position of women, they are unable to air voice to precise needs even irrespective of the fact that climate change have a varying effect on women and men in the production process (Bäthge, 2010) Irrespective of the role of women in feeding their various families and being more dependent on natural resources like as land, water and wood, their ability to access some of these resources is sometimes constrained due to some socio-cultural factors. The vulnerability of women to climate change arises from the gendered roles across society; for example, due to common restrictions on women mobility, they are less likely to get urgent information at the appropriate time to work on it (ADB, 2013). In Nigeria, studies on gender-based vulnerability climate-change effect have shown that women were more vulnerable to the effect of climate change than men (Amusa *et al,* 2015)

Livestock production accounts for the livelihood of millions of rural populations across the world irrespective of gender. Pastoral farming communities which are mainly dependent on livestock production to earn a living are not immune to the effect of climate change, but they remain one of the worst hits of climate change resulting from the response of livestock to climate variability (FAO, 2020). The impact of climate change is severe in water sources including pasture ecosystems that livestock depends on largely for survival and the increased rate of vector-conveying disease-causing organisms. Livestock farmers who majorly reside in the rural areas forms the bulk of farmers who are adversely affected by climate change. This therefore calls for an urgent need for alternative response in the form of climate-smart agricultural practices, to enable the farmers remain in production.

The link that exists between livestock production and climate change still remains unclear. However, raising animals for consumption entails the use of high amounts of water, leading to deforestation and highly contributing to greenhouse gas emissions; thus, making livestock farming to adversely damage the climate and planetary health. Researchers have suggested a number of shifts to combat this problem, including changes in diet, that can help reduce climate emissions relating to food (Hussain, 2022). The two key greenhouse gases created by farming are methane and nitrous oxide. Universally, rearing animals for consumption contributes a minimum of 16.5% of greenhouse gas with a high pollution impact. Methane, mainly produced by enteric fermentation and manure storage, is a gas that has an effect on global warming 28 times higher than carbon dioxide (Grossi *et al*, 2018; Hussain, 2022). This, therefore, calls for requisite gender-sensitive and climate-smart agricultural approaches that will enhance livestock production without negative health effects, globally.

Climate Smart Agriculture Approaches and Gender in livestock production

A gender-responsive approach to climate-smart agriculture (CSA) implies that particular needs and priorities of men and women are recognized and adequately put into consideration in the design and application of CSA to enable men and women to benefit equally (Nelson and Huyer, 2016). This approach suggests that the particular priorities, needs, and realities of both gender (men and women) need to be recognized and adequately addressed in the design and application of CSA so that men and women will benefit equally (FAO, 2015). This will entail the inclusion of women in programs enhancing agriculture and climate responsiveness so as to achieve food security and other broader development objectives in the face of changing climate and increasing food demand (Aweke, 2017). Evidence revealed that CSA initiatives have made efficient and effective productive and resilient technologies, practices, and approaches more available (Mersha and Van Laerhoven, 2016). CSA intervention initiatives have also led to increased yields, high productivity in animals, diversified crops, improved soil fertility, saved labor, and other benefits leading to efficiency in production (Sterrett, 2011). Despite these achievements, CSA initiatives repeatedly fail to account for the differences in men's and women's needs and abilities to adapt to climate change, instead have tended to have an implicit male bias with the needs and priorities of men being catered to the detriment of the women, especially in the distribution of opportunities and resources (Skinner, 2011). In Nigeria, research has shown that men were more empowered than women for the adoption of climate-smart agricultural practices (Kehinde and Shittu, 2019; Oyawole, *et al*. 2020). The attainment of positive results through interventions should be dependent on whether the measures have considered gender dimensions of climate change adaptation. For instance, understanding the cultural construction underlying the choices of animal breeds made by female and male farmers is important in devising gender-sensitive experimentation to help identify animals with high resistance to the adverse impacts of climate change. However, understanding men's and women's reactions to low production due to climate change is important to finding effective entry points for building resilience and for sustainable development. For example, men often respond to the effects of climate change by investing in short-term production of certain animals with the aim of quick income generation, while women respond by producing low-value subsistence crops and animals to meet the food demands of the family (Perez *et al*, 2015).

Climate-Smart Livestock Production Strategies

To support the design of development interventions for climate-smart livestock production, Iyiola-Tunji (2021) identified the following elements:

1. Collaborative management of natural resources: there should be a participatory approaches to sustainable management of natural resources such as land water forest and other resources so as to develop a long-term sustainable strategies. In this case, decision making processes should be designed in such a way that all the stakeholders concerned (farmers, pastoralists, herders etc.) are captured considering their peculiarities and their environment.

2. Community involvement in adaptation strategies: it is practically impossible to develop a successful adaptation strategies in isolation. Community participation in the identification of new solutions is basic to ensure the long-term sustainability of interventions. According, adaptation strategies need to be developed taking into account environmental, health and social issues such as increased migration, conflict.

3. Incentives and tailored responses: financial incentives and regulations for improving natural resource management and livestock production systems through proper pasture/land management and feeding management can be used as incentives to encourage GHG mitigation and adaptation. Indeed, the introduction of tailored index-based insurance schemes and rural finance initiatives are the keys to support livestock keepers better cope with climate change risks.

4. Subsidies: through the inclusion of subsidies or other enticements incentives in development process, cautious attention will need to be given to their effects. Though in some cases they might support adaptation strategies (i.e. promoting the introduction of heat-resistant breeds, subsidizing vaccinations to reduce vulnerability to the spread of new diseases) in others subsidies could negatively affect adaptation/mitigation strategies

5. Risk management measures: appropriate risk management mechanisms and preparedness measures are needed need to be put in place to cope with the impacts of more frequent and extreme climatic events. Preparedness approaches, early warning systems and other risk mitigation activities (i.e. strengthening infrastructures, insurance systems, forecasting, etc.) will be needed to reduce the impacts of severe weather events to prevent loss of livestock.

6. Awareness and education: availability and accessibility of relevant information regarding climate change is a vital aspect of adaptation, therefore efforts should be geared towards ensuring that knowledge among local farming communities. An understanding of the patterns of climate variability of current and projected climate and seasonal forecasts is key to anticipating shock and losses and enabling external agencies to provide necessary assistance to targeted herders.

7. Mitigation: to support the mitigation of GHG emissions efforts should focus on reforestation, improved grazing management, restoration of degraded lands, livestock manure management, improved feeding management, improved energy/feed efficiency, selection of more productive animal breeds and transhumance practices.

8. Innovation, Research and Technology development: promoting the necessary development and improved access to needed technologies and sharing knowledge on sustainable and climate-friendly farming practices is crucial. Country specific research is needed to inform the development of adaptive strategies and more focus needs to be given to 'the development of improved crop varieties and animal breeds, as well as more sustainable and integrated management of crops, animals and the natural resource base that sustain their production, while providing other important services for farmers and the environment' (IFAD, 2009) to increase resilience of developing countries.

9. Gender dimension: adaptation and mitigation strategies should consider the different roles of women and men and the way in which climate change will impact on them. Climate change clearly offers an opportunity to rethink gender inequities and to involve both women and men in proffering innovative solutions that can respond to common environmental challenges.

10. Indigenous knowledge: the in-depth understanding of the environments that local communities and indigenous peoples have, together with their experience in adapting to climate variability are key for the development of adaptation and mitigation strategies. There is therefore a need to understand the indigenous knowledge and practices of farmers so as to know which adaptation strategy that will be useful and acceptable to farmers across various locations.

Climate-Smart Agricultural Practices for Improving Livestock Production

According to FAO (2017), one way of improving livestock production is through productivity improvements to reduce emission intensities and this could be achieved through the following:

i. Feed and Nutrition: the approach of improving feed quality can be accomplished through improved grassland management, improved rangeland management, improved pasture species (e.g. grass and legumes mix), forage mix, feed processing (e.g. chopping, urea treatment) and strategic use of supplements, preferably locally available.

ii. Animal Health and Husbandry: Improving reproductive efficiency and extending the reproductive life of the animal will improve lifetime performance per animal and reduce GHG emission intensities. Reducing the incidence and impact of diseases, parasites and insect burdens will result in higher productivity and efficiency "with lower losses and less unproductive animals that emit GHG.

iii. Animal Genetic Resources and Breeding: Breeding is key to increasing productivity by improving traits such as live-weight gain and milk yield or fertility. It can also improve adaption of livestock to changing environments, resistance to stress or shocks and diseases. Well planned breeding programmes and conservation of animal genetic diversity can ensure farmers have access to the best animals in each environment.

Agricultural Extension Roles in Strengthening Livestock Systems through Climate-Smart and Gender-Sensitive Approaches

Agricultural extension is central to the development of agriculture in every nation. The role of agricultural extension in strengthening livestock systems through climate-smart and gender-sensitive approaches can be summarized as follows:

i. Linking farmers with sources of improved farm inputs in animal production: it is the role of agricultural extension service provider to link livestock farmers with improved farm inputs geared towards climate-smart agriculture. It is obvious that some improved farm inputs for climate smart agricultural practices may not be available and accessible to farmers. In most cases, even when they are available, because of the newness and peculiarity of these inputs, farmers may not be aware of their usefulness.

ii. Organization of necessary capacity building programmes for livestock farmers on climate smart agricultural practices in Livestock production. This should be combined with farm visits to practically demonstrate these climate-smart agricultural practices that will build the livestock farmers' capacity that will enhance their production performance in face of climate changes. Also, these training programmes which may take the form of seminars, workshops and forth-night trainings should take into consideration the various region or farming environment with their climate change peculiarity in livestock production and should not be gender biased.

iii. Risk management: the agricultural extension service providers should exposed livestock farmers to the available risk management options. This will enable the farmers cope with the risky aspects of their production. This is particularly important because of the risks involved in livestock production due to climate change effects on livestock. For instance, extreme high or extreme cold temperatures that might be detrimental to the health of animals.

iv. Link to sources of finance: Availability of fund is key to livestock production, with the effect of climate change there is a possibility of increased cost of production. Livestock farmers should be linked to available sources of fund. This could be in the form of low interest or subsidized loan or donor agencies who are particularly interested in funding livestock production in the face of climate change.

v. Farmers' indigenous knowledge: Human societies across the globe have specific knowledge with which they cope with changes in the environment. Extension service providers, should identify specific indigenous knowledge systems across locations for possible improvement. This will make the farmers build self-confidence and will facilitate their acceptance of innovations regarding climate-smart agricultural practices.

CONCLUSION

Livestock production accounts for the livelihood of hundreds of rural populations in Nigeria. Few women are into livestock production for only small ruminants while many men engage in cattle production and cattle grazing. Only few women accesses livestock produce (milk, beef, eggs, other meat) for processing and they lack capacity for value addition development. CSA intervention initiatives have led to increased yields, high productivity in animals, diversified crops, improved soil fertility, saved labor, and other benefits leading to efficiency in production. There is need for capacity building of both gender on the strategies to tackle the issues of climate change for enhanced production to achieve sustainable food production. Going by the adverse effect of climate change, there is the need for incentives to be made available to livestock farmers; this could be in the farm of grant and low interest loan and should target both male and female livestock farmers without disparity. This could encourage both gender remain in production in the face of the challenging effect of climate change. Climate-smart agricultural practices that require specific farm inputs should be made available to livestock farmers. This can be achieved through proper extension service delivery system tailored towards the immediate felt need of the livestock farmers without gender disparity.

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Efficacy of Carbendazim and other Synthetic Fungicides on Taro Leaf Blight Disease caused by *Phythophtora Colocasiae*

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K E Y W O R D S

Cocoyam leaf blight,
Fungicides,
Mycelia growth and resistance

A B S T R A C T

The results of the serial concentrations of different synthetic fungicides, phytopathogenic fungi and their interactions on isolates from cocoyam had significant effects (P≤0.05) on the percentage inhibition and mycelia growth. P. colocasiae (12.50 mm) treated with hexaconazole had the lowest mycelia growth rate followed by Botryodiplodia theobromea (21.28 mm) with fludioxonil and carbendazim (24.03 mm) while Rhizopus spp (85.83 mm) and F. solani (78.798 mm) on metaxyl recorded the highest mycelia growth. The effects of different environmental stress, fungi and their interaction on mycelia growth showed significant difference on the organisms, the stress and their interactions. No mycelia growth were seen when B. theobromea were subjected to H_2O_2 *(5.00 mm), followed by P.colocasia (14.67 mm).*

In conclusion, fungicides found to be effective for the control of cocoyam leaf blight in order of merit were carbendazim, fludioxonil, hexaconazole and mancozeb. Metaxyl recorded no or little effect on the inhibition of mycelia growth of all the four fungi organisms isolated from cocoyam as the organisms have developed resistance to it. It should be used in mixture with other fungicides with different mode of actions for example mancozeb.

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INTRODUCTION

Cocoyams, *Colocasia esculenta* are important perennial food crops cultivated for their edible roots (Owusu-Darko *et al*., 2014). The crop is primarily grown in tropical and sub-tropical countries and is one of the major food crops in Nigeria (Aniekwe, 2015, Omeje *et al*., 2015).

Despite their importance and usage, their production in Nigeria are heavily affected by plant diseases especially fungi including; *Phyllosticta colocasiophila*, *Phytophthora colocasia, Fusarium spp, Phythium spp, Aspergillus niger, Sclerotia rolfsii* and *Botryodiplodia theobromae* (Anukworji *et al*., 2012; Omeje *et al*., 2015) but the most devastating fungus is *P. colocasia* which causes leaf blight. Symptoms are small, brown, water-soaked lesions on the leaves which enlarge and coalesce into large lesions with yellow exudate, defoliation and death.

The infection of taro leaf blight has reduced taro production rate by 30-40%, leading to heavy reduction in quality and quantity of corm and hindering the commercialization of taro corm product in many taro producing countries (Bandyopadhyay *et al*., 2011; Mbong *et al*., 2013). Control measures need to be adopted to reduce the effect of taro leaf blight (TLB) below its economic injury level and hence increase taro production. TLB has been controlled using cultural strategies including field sanitation, roguing, clean planting stocks, and use of resistant varieties (Aggarwal and Mehrotra, 1987; Nelson *et al*., 2011) such as *Trichoderma* species, *Rhizobacterium* species) (Chukwu and Enyiukwu, 2021). However, due to the drastic reduction in yield of taro, the use of fungicide is justified to ensure quick response.

Fungal infection has been worldwide estimated to reduce yield of crops to 20% if not treated, thus use of fungicides has become wide spread recently in Agriculture (Rohr *et al*., 2017). Fungicide controls the fungal infection during the establishment and growth of a crop, it enhances the productivity of crop and decrease defects (Bandyopadhyay *et al*., 2011). Some fungicides that can be used to control taro leaf blight disease includes single or compound synthetic fungicides such as mancozeb, diflolatan, and ridomil (metalaxyl) or copper (Aggarwal and Mehrotra, 1987; Cox and Kasimani, 1988).

To improve the efficiency of production, this fungus must be controlled and managed through the use of some synthetic fungicide benzimidazole.

Benzimidazoles is a group of fungicides commercially available as benomyl, carbendazim (MBC), thiophanate-methyl, thiabendazole and fuberidazol, known for their broad-spectrum activities against several fungal pathogens namely ascomycetes, some basidiomycetes and deuteromycetes (Leadbeater, 2014). These fungicides can be applied to cereals, fruits, vegetables and vines and also used in postharvest handling of crops (Duan *et al*., 2014; Y. Duan *et al*., 2019; Oliver and Hewitt, 2014) against *Cercospora spp*., *F. spp*, *Botrytis cinerea Colletochrichum spp*., powdery mildew, *Erysiphe spp* and *Oidium spp* crops (Duan *et al*., 2019; Oliver and Hewitt, 2014). Carbendazim is the most common and widely used to manage crop diseases in cereals, roots and fruits (Zhou *et al*., 2016). The combination of carbendazim and diethofencarb is a good control measure against *B. cinerea* although the appearance and spread of the two fungicides caused problems (Leroux and Fritz, 1984).

Benzimidazoles interrupt pathogen energy metabolism through their selective bindings with high affinity to pathogen β-tubulin and inhibition of microtubule polymerization resulting to destruction of cell structure and death of pathogen. They are the important inhibitors of β-tubulin polymerization against several plant pathogenic fungi such as *B. cinerea, Cercospora spp*., *C. spp*., *F. spp*., *E. spp* and *O. spp* (Duan *et al*., 2019). This study was therefore, to determine the efficacy of synthetic fungicide carbendazim on the leaf blight of cocoyam caused by *P. colocasiae* with the following objectives to:

(a) Determine the sensitivity and resistance of *P. colocasiae* to carbendazim.
(b) Assess the effect of carbendazim and other fungicides on other fungi organisms associated with cocoyam
(c) Evaluate the effect of *P. colocasiae* and other fungi organisms isolated from cocoyam on environmental stress

MATERIALS AND METHODS

Experiment sites

Laboratory experiments were conducted at the Department of Crop Science, Teaching and Research Farm, Faculty of Agriculture, University of Nigeria, Nsukka.

Collection of P. colocasiae isolates

Cocoyam leaves with leaf blight symptoms were collected from Department of Crop Science research farm, University of Nigeria, Nsukka. The leaves were disinfected with 0.5% (vol/vol) of Naclo for 1 minute and 75% (vol/vol) ethanol for 30s, rinsed three times with distilled water and cultured in potato dextrose agar (PDA) plates PDA which contains 200g of boiled potato tubers, 20g of dextrose and 15g of agar with distilled water per litre, amended with streptomycin sulfate (98% a.i., 50 μg/ml; Solarbio Science and Technology Co., Ltd., Beijing, China) and incubated for 3 days. Mycelia growth emerging were cut from the colony margins and transferred to fresh PDA plates. Pure cultures of the isolates were collected by sub-culturing on PDA under 12/12h light/darkness photoperiod using near-ultraviolet (NUV) light at 25 ^{0}C. a single conidium of the isolates obtained were maintained PDA slant at 4 ^{0}C for further use.

Fungicides and media

All fungicides of pure technical grade were used for the experiment. Fludioxonil (97.9% a.i.), carbendazim (98% a.i), metalxyl, mancozeb and hexaconazole (98.7% a.i.) were dissolved in methanol to obtain 10^4 (μg) ML^{-1} of the stock solution were preserved in the dark at 4 ^{0}C. PDA were prepared with 200g of potato, 20 g of glucose and 16 g of agar L^{-1} of distilled water where Potato dextrose broth (PDB) used for these experiments also has the same composition but lacks agar.

Evaluation of sensitivity of *P. colocasia* to carbendazim

The sensitivity and resistance test of *P. colocasia* and other fungi organisms isolated from cocoyam were estimated using mycelia growth assay. The other fungi organisms were *Fusarium solani, Rhizopus spp* and *Botryodioplodia theobromea*.

Mycelia plugs (5-mm in diameter) were prepared from one-third outside of the active margin of colony, transferred to new PDA plates and used for the experiment treated with carbendazim, mancozeb, metalaxyl, fludioxonil and hexaconazole at the serial concentrations of 0, 10, 20, 40, 80 and 100 μg/ml and incubated at 25 0C for 6 days. The diameters were investigated when the colonies without fungicide approached to eight cm. Data on mycelia growth in terms of colony diameter were obtained by averaging the diameters at perpendicular directions from which 5-mm in diameter were subtracted. The percentages of growth inhibition was calculated and arcsine-transformed prior to statistical analysis using the percentage transformation formula (Inhibition rate = ARSIN (SQRT (ab/100))*180/3.1415926) prior to statistical analysis. The treatments were replicated three times for each strain of the six pathogens and experiments performed two times.

Virulence test assay

To determine whether the organisms associated with cocoyam leaves can cause infection, virulence test assay were done on healthy cocoyam leaves.

Mycelia plugs (5mm in diameter) from a 6 days old PDA culture of each isolates were placed on the surface of the fruits over artificial wound for easy penetration of the pathogen, keep moist with a piece of moistened absorbent cotton and incubated in a growth chamber at 25 0C under 12-h photoperiod and 85% relative humidity. After 6 days, lesion diameters were measured as the mean of two diameters (cm) at perpendicular angles. The experiment was done two times with three replications

Osmotic stress assay

Mycelia plug (5mm in diameter) was taken from the edge of a 5 days old colony and transferred to PDA amended with 1.2 M NaCl, 1.2 M KCl, 0.5 M $CaCl_2$, 0.3 mg/ml Congo red and 32µg/ml H_2O_2. PDA without osmoticum served a control; each treatment was replicated three times and incubated at 25 ^{0}C for seven days. The percentages of growth inhibition were calculated and arcsine-transformed prior to statistical analysis as they were not evenly distributed. The experiment was conducted two times.

Experimental design

The experiments were laid out as factors in a completely randomized design (CRD) with three replications. Factor A were the different plant fungi, factor B were the fungicides and factor C were different concentrations.

Statistical analysis

Data were analyzed using a GENSTAT statistical software package, 12.0 Release 4.23 (Payne, 2009). Colony diameters, mycelia weights and lesion areas were estimated in a completely randomized design (CRD) with three replications. Means were compared with Fisher's protected least significant difference at 5% probability level as outlined by (Obi, 2002).

RESULTS

Evaluation of sensitivity of *P. colocasia* to carbendazim and other fungicides

The results showed that serial concentrations of different synthetic fungicides, phytopathogenic fungi and their interactions had significant effect ($P \leq 0.05$) on the percentage inhibition and mycelia growth of isolates from cocoyam. Five fungicides at concentrations: 0.10, 20, 40, 80 and 100 µg/ml evaluated *in vitro* against *P. colocasiae, F. solani, R. spp* and *B. theobromea* exhibited wide range of mycelia growth and inhibition of the pathogens. *P. colocasia*e (12.50 mm) treated with hexaconazole had the lowest mycelia growth rate followed by *Botryodiplodia theobromea* (21.28 mm) with fipronil and carbendazim (24.03 mm) while *Rhizopus spp* (85.83 mm) and *F. solani* (78.798 mm) on metaxyl recorded the highest mycelia growth (Fig 1). Low mycelia growths were seen on all fungal isolates tested on concentration 100 µg/ml when compared with the untreated plates (Fig 2). Concentration 100 µg/ml of carbendazim (7.00 mm) and mancozeb (5.00 mm) recorded the lowest mycelia growth (Fig 3). The organism *B. theobromea* at concentrations 10, 20, 40, 80 and 100 µg/ml of carbendazim and 80 and 100 µg/ml of mancozeb did not grow likewise *P. colocasiae* at concentrations 10 -100 µg/ml of hexaconazole and 20 -100 µg/ml of carbendazim. Concentrations 40 – 100 µg/ml of carbedazim did not allow rhizopus to grow (Fig 4). The results revealed that all the five fungicides tested at concentrations 40 -100 µg/ml significantly inhibited mycelial growth over untreated plates. Furthermore, the percentage mycelia growth inhibition of carbendazim and mancozeb increased with increased in concentration of fungicides tested. Highest percentage inhibitions of *P. colocasiae* were observed on hexaconazle (83.33%) and carbendazim (75.97%). However, fungicides carbendazim, fipronil, hexaconazole and mancozeb were considered to be good for the inhibition of *B. theobromea* and *P. colocasiae*. The effects of different environmental stress, fungi and their interaction on mycelia growth showed significant difference on the organisms, the stress and their interactions. No mycelia growth were seen when *B. theobromea* were subjected to H_2O_2 (5.00 mm), followed by *P.colocasia* (14.67 mm) (Fig 5).

Table 1: Mycelia growth rate and virulence test assay of *P. colocasia* , *B.theobromea, R. spp* and *solani*

Fungi	**Virulence assay**	**mycelia weight**
Rhizopus spp	8.5 b	0.023
B. theobromea	10 b	0.104
F. solani	19.17 a	0.062
P. colocasia	10 b	0.453
F-LSD $_{(0.05)}$	3.863	NS

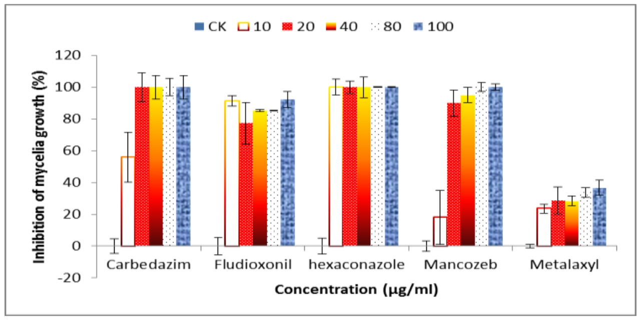

Fig 1: Effects of different synthetic fungicides and their concentration on the percentage inhibition of mycelia growth of *Phytophthora colocasiae.*

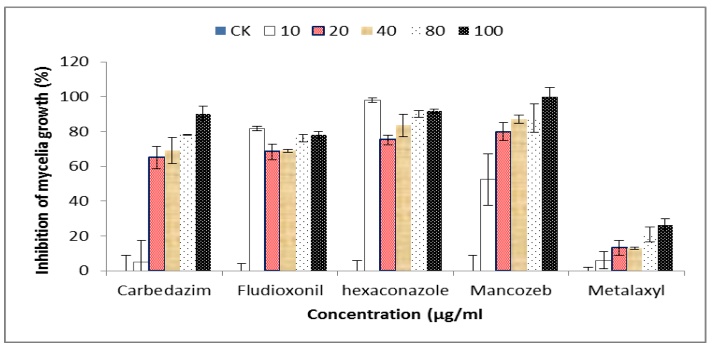

Fig 2: Effects of different synthetic fungicides and their concentration on the percentage inhibition of mycelia growth of *Fusarium solani***.**

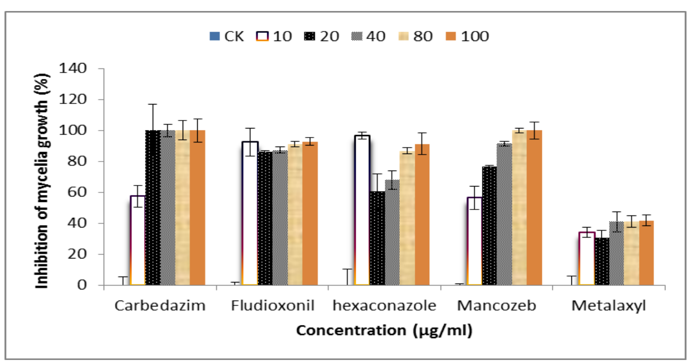

Fig 3: Effects of different synthetic fungicides and their concentration on the percentage inhibition of mycelia growth of *Botryodiploma theobromea.*

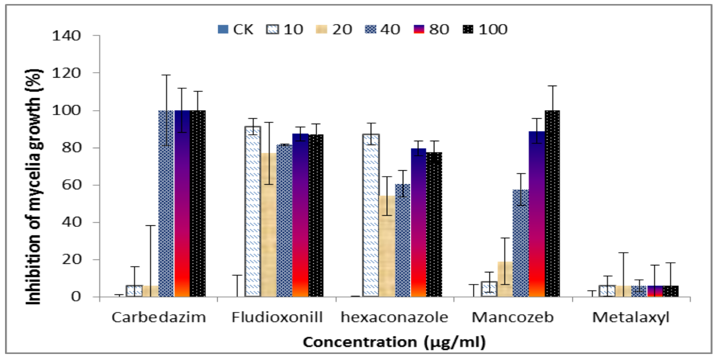

Fig 4: Effects of different synthetic fungicides and their concentration on the percentage inhibition of mycelia growth of *Rhizopus spp.*

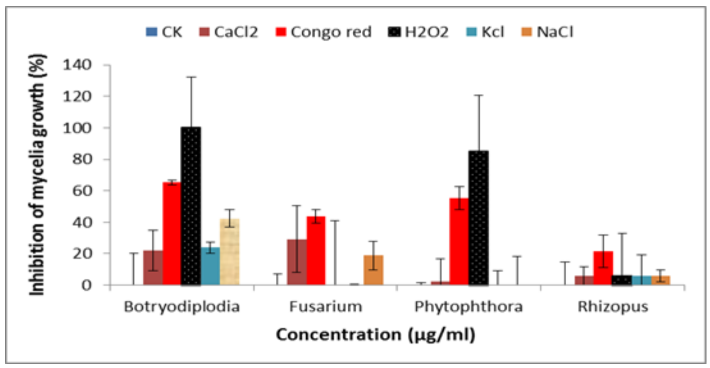

Fig 5: Effects of different environmental stress on the percentage inhibition of mycelia growth of different fungi organisms isolated from cocoyam.

DISCUSSION

The results revealed that all the five fungicides tested at concentrations 40 -100 µg/ml significantly inhibited mycelial growth over untreated plates. Furthermore, the percentage mycelia growth inhibition of carbendazim and mancozeb increased with increased in concentration of fungicides tested. Highest percentage inhibitions of P. colocasiae were observed on hexaconazle (83.33%) and carbendazim (75.97%). However, fungicides carbendazim, hexaconazole , mancozeb, and fludioxonil were considered to be more effective in the inhibition of *B. theobromea* and *P. colocasiae.*

Early research on the mechanism of action of carbedazim dwell on DNA and RNA synthesis which were described as secondary and primary effects respectively (Davidse, 1995;Davidse, 1986). In arresting nuclear division of fungi, carbendazim fungicide gives a striking resemblance to secondary plant metabolite colchicine, which disrupt mitosis and meiosis in animal and plant cells by inactivating the spindle (Zhou *et al*., 2016). The biochemical analysis of mechanism of action of carbendazim indicate the antimitotic activity of carbendazim in fungi facilitated through binding to fungal tubulin (Davidse, 1995; Zhou *et al*., 2016). They are greatly important in controlling many plant pathogenic diseases of crops. Carbendazim is a strong inhibitor of tubulin polymerization, antifungal in action and interfere with parasites energy metabolism through their selective bindings with high affinity to pathogen β-tubulin resulting to destruction of cell structure and death of pathogen (Chen *et al*., 2009; Lacey, 1990; Prichard, 1970a, 1970b; Schmit, 2013; Tejada *et al*., 1987; Y. Zhou *et al*., 2016). Hexaconazole is used widely for the management of anthracnose, powdery mildew, late blight, early blight, downy mildew and grey mildew diseases on crops due to its broad spectrum activity (Zhou *et al*., 2017).

Metalaxyl spectrum of activity broadened to control more diseases when it is used with other fungicides such as dithiocarbamate, phythalimides or copper fungicides and at the same time thus buildup of resistant fungal strains may be delayed and prevented (Sukul and Spiteller, 2000; Yao *et al*., 2009). Metalaxyl inhibits ribosomal RNA synthesis through RNA polymerization by acting on the polymerase 1 complex of rRNA synthesis which is the target site (Agrios, 2005). Resistance isolates of metalaxyl were detected in *Pseudoperenospora cubensis, P. infestans, P. tabacina* and *P. viticola*, therefore it was recommended that it should use in mixture with other fungicides with different mode of actions for example mancozeb (Agrios, 2005)

The effects of different environmental stress, fungi and their interaction on mycelia growth showed significant difference on the organisms, the stress and their interactions. No mycelia growth were seen when *B. theobromea* were subjected to H_2O_2 (5.00 mm), followed by *P.colocasia* (14.67 mm).

In conclusion, fungicides found to be effective for the control of cocoyam leaf blight in order of merit were carbendazim, fludioxonil, hexaconazole and mancozeb. Metaxyl recorded no or little effect on the inhibition of mycelia growth of all the four fungi organisms isolated from cocoyam as the organisms have developed resistance to it. It should be used in mixture with other fungicides with different mode of actions for example mancozeb.

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Awareness of Hazardous Implication of Agrochemicals used in Dabar Kwari Dawakin Kudu Local Government Area of Kano State, Nigeria

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ABSTRACT

Improper uses, handling and disposal Agrochemical could have adverse health and environmental pollution Dabar kwari in dawakin kudu is selected due it higher numbers of farmers, it is surrounded with lake and other source of irrigation farming. The main objectives are assessing the knowledge and practice regarding uses, handling Agrochemical and disposal of it. 200 farmers were randomly selected from Dabar Kwari. 70.5% used Agrochemical in the farm without protective equipment, 35.4% uses their bare hands in mixing Insecticide, herbicide and pesticide, and more 80.0% wash Agrochemical containers in the lakes surrounding the village with is main sources of water for the community, most of the farmers store Agrochemical at home. The ability to apply the right quantity of Agrochemical is low. On average the respondents have low awareness of heath implication of Agrochemical. State, Local Government and NGO can create awareness for safety measure, handling and disposal of Agrochemical among farmers and sellers of Agrochemicals. Though number of children in school, Radio program, and training program in the field. It is there recommended to included Agrochemical safety in our primary and secondary curriculum.

INTRODUCTION

Food production is one of the main sources of Economy in Nigeria. Agro chemical is any chemical is used in agricultural production to improve productivity and control pest and diseases (Omari 2014) Many of the chemical pesticides can have harmful effects on human beings either as acute or chronic toxicity. Acute exposure to pesticides can lead to death or serious illnesses. About 355,000 people die globally each year due to unintentional acute poisonings.[7] Two-thirds of these deaths occur in developing countries where such poisonings are associated with excessive exposure and or inappropriate use of toxic chemicals and pesticides present in occupational and domestic environments. The cumulative health impacts of human exposures to various agrochemicals can be a factor in a range of chronic health conditions and diseases like cancer, reproductive, endocrine, immunological, congenital and developmental disorders (Jurewicz and Hanke 2008). Achieving food security, addressing climate change, and halting environmental and natural resource degradation are among the key challenges the agricultural sector faces in efforts to achieve sustainable development goals (SDGs[1]) and the Paris Agreement to limit the global temperature increase to below 2 °C (Wollenberg *et al.*, 2016).

Agrochemical mishandling constitutes one of the most several farm operation hazards confronting farmers, their produce, and the environment. Wrong application time and dosage, mishandling, ignorance of safety precautions, and the use of adulterated or expired agrochemicals in circulation have been shown to impact both aquatic and terrestrial ecosystems and degrade the quality of groundwater destined for human consumption (Nikolaidis *et al.,* 2007; Tekwa *et al.,* 2010)

Many farmers do not have adequate knowledge and information on health implication associated with handling and use of pesticides (Okoffo *et al.,* 2016). The use of personal protective equipment (PPE) remains a thing of choice to the Farmers. Other precautionary measures like avoiding eating, drinking, and smoking during application is still not adhere by the farmers. Instead of farmers to properly dispose empty containers of Agro chemicals, they use them for fetching water, keep cooked food. The ablity to apply the right quantity is dependent on awareness of the health. The use of pesticide continues as agricultural production intensifies. However agricultural production is fraught with abuse, misuse and over use of the chemicals (Asante and Ntow 2009). Though the benefits are substantial, studies have associated the use of certain agrochemicals with some important environmental and health damages (Clarke *et al.,* 1997; WHO, 1997; Krebs *et al.,* 1999; Greenpeace, 2008). This Research has primarily focused on toxicity, hazardous and mishandling Agrochemical among our Farmers health and the environment.

MATERIAL AND METHODS

The study was conducted within the Dabar kwari Dawakin kudu Local Government in Kano State which occupies about 100 square kilometres of land, with population of about 60,000. 90% of its population engaged in subsistence and commercial farming. Mixed cropping is practiced by most farmers with most crops grown for home consumption. A questionnaire was designed in English and translated into Hausa as local language that is understood by majority of the farmers, and was administered to 200 Farmers verbally in Hausa. Questions were in a multiple choice format so that respondents had to select only the appropriate answer or answers that they thought well described their opinion or attitude on a particular issue. The questionnaire contained three main sections. The first section was designed to collect information on personal characteristics of the farmers including age, educational level, and years of farming experience. The second section focused on collecting information on farmers' level of awareness of pesticide laws and regulations, and knowledge and understanding of pesticides with respect to the environmental and human health. In addition, we also collected data of knowledge on hazard nature of Agrochemicals. The third section included questions regarding pesticide handling and safety practices including reading and following label instructions, storing and disposing of pesticides and empty containers, and use of PPE and other protective practices during and after pesticide application.

RESULTS

Characteristics and Profile of the Farmers

All farmers surveyed in the study were men, as farming activities especially those related to pesticide use are performed exclusively by men in Dabar Kwari. The majority of the farmers are male nearly all farmers (90%) were within the young and middle age category (≤ 55 years) while only 3% were aged more than 60 years. Furthermore, most farmers were married, followed by divorced, with the widowed being the least. Data shown in Table 1 also indicated 42% attended Qur'an school 36% of the farmers had attained education up to primary level, 20% up to secondary level, and 2% up to tertiary level. This is an indication that farming is not attractive to tertiary education graduates. However, none of the farmers were illiterate. Majority of the farmers (37%) considered farming a temporary or part-time occupation whilst 63% were full-time employed farmers. Furthermore, whiles more than half of the farmers had other source of income.

Table 1: Summary of the characteristics of farmers in the study area (n = 100)

Selected Characteristics	Categories	Frequency (%)
Gender	Male	85
	Female	15
Age (years)	Young (18 – 30)	28
	Medium (31 – 50)	69
	Older (>60)	3
Marital status	Married	61
	Single	18
	Widowed	3
	Divorced	18
Employment status as farmer	Full-Time	63
	Temporary/Casual	37
Role/status household	Head	85
	Spouse	15
Educational Level	Qur'an Schools	42
	Up to Primary Education	36
	Up to Secondary Education	20
	Up to Tertiary Education	2

Farmers' Knowledge, Attitude, and Understanding about Agrochemicals

The farmers' level of knowledge of Agrochemical, including exposure routes, effects on the environment and human health, and their awareness of pesticide laws and regulations was analyzed in Table 2. The majority (86%) of the farmers had not received any training on safe handling of pesticides herbicide and insecticide, while 14% were trained. Although most farmers agreed that pesticide use poses some risk to human health (71%) and the environment (65%), they also indicated that pesticides were indispensable for high crop yield (80%). Over 60% of the farmers did not read or follow instructions on Agrochemicals labels, because they were unable to read and understand the meaning of the labels (56%), the labels were written in English (a foreign language like Chinese).

Table 2: Summary of the characteristics of farmers in the study area (n = 100)

Selected Characteristics	Categories	Frequency (%)
Training on safe handling	Yes	14
	No	86
Risk on Health	Yes	71
	No	29
High crop yield by pesticide	Yes	69
	No	31
Follow label on Agrochemicals	Yes	40
	No	60
Understanding the level	Yes	44
	No	56

Agrochemical use, human health and the environment hazard

In Table 3, most farmers (86%) used various types of agrochemicals on their farms. 70.5% used Agrochemical in the farm without protective equipment, 35.4% uses their bare hands in mixing Insecticide, herbicide and pesticide, and more 80.0% wash Agrochemical containers in the lakes and river around them, most of the farmers store Agrochemical at home.

Table 3: Farmers' Responses to Selected Characteristics (n = 100)

Selected Characteristics	Categories	Frequency (%)
Use Agrochemical on farm	Yes	86
	No	14
Mixing of 2 or more Agrochemicals with bare hand	Yes	70
	No	30
Wearing of protective clothes before use of Agrochemicals	Yes	20
	No	80
wash Agrochemical containers in the lakes and river	Yes	80
	No	20
Stored Agrochemical at home.	Yes	95
	No	5

DISCUSSION

Generally very few of the farmers interviewed were female and this was because most of the female farmers were reluctant to be interview compared to the male. Again, women generally faced more constraint than men in accessing productive resources, markets and services; and this "gender gap" tends to hinder their productivity and reduce their contributions to the agriculture sector and to the achievement of broader economic and social development goals (FAO, 2011).

Understanding farmers' level of knowledge and practices regarding the safe use of Agrochemicals is vital for providing sound educational and policy strategies that aim at limiting the health and environmental hazards caused by it. The majority of farmers in this study were well aware of the harmful effects of Agrochemicals with regard to the environment and human health, but contrary to expectations, this did not significantly change their practices or attitudes towards safe pesticide use. This suggests that even though farmers may know the hazards of pesticides very well, they may often adopt risky behaviors because of lack of education and poor knowledge and understanding of safe practices in pesticide, insecticide and herbicides uses (Khan and Ilahi 2019) The low access to extension and research program by farmers could be attributed to the inadequate number of skilled staff for such programmers and this affects the activities of farmers in terms of awareness of modern agricultural practices. The percentage of farmers who used agrochemicals is high. The perceived low awareness of the hazards associated with the use of agrochemicals among the farmers interviewed could be attributed to the low educational level as corroborated by Ibitayo (2006). There is high probability that a greater percentage of farmers with higher educational background read the labels on the agrochemicals before purchase and use and this category of farmers are conscious of the expiry date and the implications of their activities on the environment. In a study, Islam and Kashem (2000)

Use of appropriate PPE, such as coveralls, and the adoption of other protective measures and good personal hygiene such as showering, not smoking, eating or drinking while handling pesticides are considered good practices to reduce occupational pesticide exposure.

The failure of farmers to read the labels could mean that, unaware, these farmers are using expired chemicals/fake chemicals. The combination of two or more agrochemicals before application has associated effects on the environment. Generally, the efficacy of a cocktail of chemicals could be predicted from the impact of individual chemical. The components of a mixture can react together to form another compound that may have a higher or lower potency than the individual chemicals (Olayiwola, *et al.,* 2017).

CONCLUSION

Though agrochemicals help improve productivity, wrong application time and dosage, mishandling, ignorance of safety precautions, and the use of adulterated or expired agrochemicals have deleterious effects on the environment and human health. This study has revealed that most farmers have low levels of awareness of the negative effects of the use of agrochemicals on themselves, consumers of their produces and the environment. Increased accessibility to extension and research programmes should be encouraged by all major stakeholders in agriculture. Also modern trends of agricultural practices that present fewer hazards to environment and health should be advocated. State, Local Government and NGO can create awareness for safety measure, handling and disposal of Agrochemical among farmers and sellers of Agrochemicals. Though enrollments of children to school, Radio program, and training program in the field. It is there recommended to included Agrochemical safety in our primary and secondary curriculum

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Revenue and Income Analysis of Fresh pepper Marketing in Aba North Local Government, Abia State, Nigeria

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ABSTRACT

The study examined revenue and income analysis of fresh pepper marketing in Aba North local government area, Abia State, Nigeria. Specifically, it described the socioeconomic characteristics of the marketers, marking channel and volume of trade among the channels, profitability and economic efficiency of the marketers and constraints to pepper marketing in the study area. A multistage sampling procedure involving simple random sampling methods were used to select one hundred and twenty five marketers. Primary data were collected by means of structured questionnaire and were analyzed using descriptive statistics, enterprise budgeting, Sherpherd-Futrell technique and relative importance index. Finding from socioeconomic characteristics showed that majority of the marketers were within the age bracket of 30 and 49 implying that the marketers are young, energetic, flexible in accepting new ideas and taking risk and there is a female. The result of marketing channel revealed that third channel recorded the highest percentage of (64%). The result of profitability of fresh pepper marketing showed that out of the total cost of ₦628, 257.5 spent by the marketers, purchases constituted (89.39%) while the least expense was interest on loan (2.68%). The enterprise generated a net return on investment of 0.3266 and the implication of this is that the marketers return 33 kobo for every 1 Naira invested in the enterprise. Decay and Rotting (Perishability), price fluctuation, Sit-at-home palaver and Cough and Catarrh were perceived as the most serious constraints in the enterprise. Stakeholders should address the economic sabotage of sit-at-home palaver which is adversely affecting perishable produce were recommended among others.

INTRODUCTION

Nigeria agriculture is the major source of food and accounts for about 35% of the Gross Domestic Product (GDP), 37% of merchandised export, 75% of the rural household income and 70% of employment (Gbughemobi, Nkamigbo and Meludu, 2021). Agricultural sector is an engine room for sustaining growth of Nigeria economy and still remain the mainstay of our economy by providing food for the teeming population, create jobs as well as wealth, raw materials for industrial sector and foreign exchange earnings. Nigeria is one of the sub Saharan African countries of which agriculture was the back bone of her economy before the oil boom of 1970s (Nkamigbo, Isibor and Ekeke, 2021).

Pepper (*Capsicum specie*) is a genus of plant from the family *Solanacea* used as spices, vegetables or drugs. They are commonly called chilli, red, green pepper or just pepper (Brinker, 2009, Dimelu, 2010 and Ibitoye, Oyibo and Shaibu, 2019). It is an important agricultural crop not only because of its economic importance but due to the nutritional and medicinal value of its fruits as well as being an excellent source of natural colours and antioxidant compound (Alawode and Abegunde, 2016). Pepper is one widely used food crop and mostly grown spice crop in the world (Ugwu, 2016). It is ranked third among the world's most important vegetable crops after tomato and onion and considered the first spice to have been used by humans (Stoeffel, 2013). Adaigho and Tibi (2018) opined that pepper is one of the varied and widely used spices in the world, highly value crop that is grown for cash by farmers all over the world.

Pepper originated in Mexico around 7500BC and was introduced to England and Central Europe in 1548 and 1585 respectively. There are about 22 wild species and mostly five are widely domesticated and these are Cannum L., C. frutescent L., C. chinenses, C.

baccatum l and C.pubenscens R. (Bosland and Votawa, 2000). Pepper is mostly grown type of specie providing colour and flavor to food while providing essential nutrient requirements at the same time. The capsicum fruit is an excellent source of natural, micronutrient antioxidants (Vitamins C, E and Carotenoids) which appear to be critically important in preventing chronic and age related diseases) (Delegan (Bosland and Votawa, 2000, 2011 and Ibitoye, *et al*. 2019). Alawode and Abegunde (2016) stated that statistics estimated world production of pepper in 2001 at 21.3 million tonnnes from a harvested area of 1.6 million and Nigeria is one of the major producers of pepper in the world accounting for about 50% of the African production. The fruits from hot type pepper plant are historically employed in traditional medicine and are being used in modern herbology and conventional medicine (Paleecciteh and Craker, 1996 as cited by Delegan, 2011).Pepper is a rich source of Vitamin A and E and Vitamin C that helps in preventing clods in human than any other vegetable crop. Pepper contains high amount of pro vitamins A, B, Citrin B_1(thiamine), B_2 (riboflavin) and B_3 (niacin) and in addition to vitamins, pepper acts as therapeutic agent for cancer. Pepper stimulates the flow of saliva and gastric juice, raises body temperature, relieves cramps, improves complexion and soothe gout.

Pepper is widely grown primary for its pungency due to concentration of the alkaloid, capsoicnoid that makes pepper an important ingredient used for spice commodity in the world (Bosland and Votalla, 2000, Dipeolu and Akinbade ,2007, Abdel, 2008 and Ibitoye, *et al*., 2019).

In many household, pepper provides variety of needs such as enhancing intake of dull diets, storing grains and as mild drugs (Bosland and Votalla, 2000). It is also used in stew and some local dishes all over the Country although the type's quantities utilized vary in different areas. Pepper is used for production of spice blends, use to decorate food to give it a pungent flavor, industrial use in pharmaceutical, offer relieve from colds, sore throats, fever, enhances blood circulation for cold hands and feet, regulates blood sugar, serves as heart stimulates, regulates blood flow, useful in preparing creams meant for lessening pains, inflammations and itching as well (Adaigho and Tibi, 2018). Opata, Ezeibe and Arua (2019) reported that pepper in combination with other crops offers a source of food and income security to farmers, providing trade and employment to about 70% of local labour population in South East.

Agricultural business includes all the activities within the agricultural food and natural resource industries that are involve in the production of food and fiber. Individual agribusiness may sell items to farmers for production, provide service to other agricultural business or be engaged in the marketing, transporting, processing and distribution of agricultural products (Saunders, 2012). In Nigeria, Agribusiness provides people with food, clothing and shelter. It helps in Nigeria economy by providing jobs for millions of people in science, research, engineering, education, advertisement, government agencies, trade organizations and commodity. In Agricultural business activities, social network cannot be left behind to achieve agricultural development.

Udegbe, Udegbe, Olumoko and Hassan (2012) further explained that the participants in pepper distribution and marketing include the producer (farmer), the assembler, the wholesaler, the retailer and finally the consumer. Isibor, Nkamigbo and Ekeke (2021) reported that marketing involves all processes in the movement of products that consumers need from the point of production to the point of purchase. Marketing can contribute to economic development in Nigeria by stimulating production and consumption, facilitating income to individuals and foreign exchange earnings to the Nation.

MARTERIALS AND METHOD

The study was carried in Aba North Local government area, Abia State. It lies along the west bank of the Aba River at the intersection of roads from Port Harcourt, Owerri, Umuahia, Ikot Ekpene,and Ikot Abasi (Opobo). The Capital of Aba North LGA is Umuahia, although the major commercial city is Aba, formerly a British Colonial government outpost. Aba LGA comprises of seven communities namely Ebenji, Umuola-Okpulor, Eziama, Osusu, Umuokoji, Uratta, Umuola-Egbelu. It has a density of 35,000/km^2, Lattitude 5. 1268^{0}N and longitude 7.3679^{0}E, land area of 49KM^2 and a population of 423,852 (NPC, 2006). The study population was made up of all the pepper marketers in the Aba LGA. Multistage and simple random methods were used to select five Communities, 5 daily markets and 125 marketers (respondents) for the study.

Stage one: Five Communities were randomly selected from the entire LGA

Stage two: This involves purposive selection of one daily market with large number of consumers from each of the selected communities (Chima avenue market, Morning market, Ultru market, Eziukwu market and Urata market).

Stage three: This involve random selection of twenty five marketers (respondents) from each of the markets earlier selected making it a total of 125 marketers for the study.

Method of Data Collection and analysis

Data for the study was collected from primary source. Primary data were obtained using well-structured questionnaire to the respondents from the list of pepper marketers that constituted the sampling frame for the study. The objectives of the study were achieved through the following analytical tools. Descriptive statistics such as tables, means, and percentages were used to describe some objectives (socioeconomic characteristics of the marketers, marketing channels and volume of trade), Enterprise budgetary and

Sherpherd Futrell techniques were used to achieve profitability and economic efficiency while relative importance index was used to achieve constraints to pepper marketing.

Model specification

The model was used to measure the influence of socio-economic characteristics on net marketing income of farmers. Socioeconomic factors are as follows:

NMI=Net Marketing Income
AGE= Age in years
GEN = Gender (dummy: male =0; female = 1)
MRS = Marital status
EDU = Educational level
SOF = Source of finance
HOS = Household size (number of persons living together)
TOU = Membership of trade union (dummy: member =0, non-member = 1)
EXP = Marketing experience
MKS = Marketing cost
PDP = Product price
e = Stochastic error term.
It is implicitly represented below as
$NMI = \beta\ (AGE_1, GEN_2, MRS_3, EDU_4, SOF_5, HOS_6, TOU_7, EXP_8, MKS_9, PDP_{10} \ldots\ldots e_1)$
The budgetary technique was used to determine the profitability of the marketers
$NER=\sum P_{yxi}Y_i-(\sum P_{xij}X_{ij} + \sum F_{ij})$
Where $\sum$ =sum
$P_{yi}Y_i$= unit price × quantity of ith respondents sales = Total revenue (TR) for ith respondent.
$P_{xij}X_{ij}$ = Prices X quantities of ith respondents variable inputs= total variable cost (TVC) for jth respondent.
F_{ij} = Depreciation values of equipment, annual rent for store, interest on loan, for jth respondents = Total fixed cost (TFC) for jth respondent.
TC = Total cost (TVC + TFC).
The marketing efficiency of marketers' was achieved using Sherpherd-Futrell technique.
The marketing efficiency

$$ME = \frac{TC}{TR} \times \frac{100}{1}$$

Where:

ME = coefficient of marketing efficiency

TC = Total marketing cost incurred

TR= Total value of product sold

Constraining variables

The relative importance index was used in determining the degree of importance of the problem. To make inferential statement, the mean score was compared with the critical mean, 2.5. If the calculated mean of a problem is greater than the standard critical value, then the problem is regarded as very serious.

RESULTS AND DISCUSSION

Socioeconomic characteristics of the marketers

Socioeconomic characteristics of the marketers in Table 1 indicates that majority of the marketers were within the age bracket of 30 and 49 years. This implies that the marketers are young, energetic, flexible in accepting new ideas and taking risk. This agrees with Nkamigbo, Chiekezie and Ozor, (2019) who stated that fresh tomatoes marketers in Nnewi Metropolis were relatively young, energetic and able to face the hustle of perishable marketing. The result revealed a female dominance (84.8%) in the study area. Most women in the study area engage in petty trading in order to assist their household due to economic hardship thereby they prefer little business with a minimal capital like pepper marketing. This agrees with Udegbe, Olumoko and Hassan, (2012) who reported in their study area that pepper marketing is more of female than male. The result indicates that majority of the marketers were married (86.4%) with a 60% of household size of 4- 6 persons. Also, the educational level of the marketers is interesting implying that majority of the marketers had one level of education or the other thus making the study area a vibrant centre in business activity as Aba is known as small China. This agrees with Agbugba, Nweze, Achike and Obi (2013) who noted in their study area that high percentage of the marketers had formal education and some to tertiary education. From the result most marketers have spent 5-9 years (60.8%) in the enterprise. Source of finance revealed that friends and relative took the center stage (69.6%) implying that, in the study area most family members do help their wives/relatives to set up a business for their common goal. The result revealed that most of them belong to their trade union (91.2%) to carter for their welfare. Also, most of them engage in other trading activity due to the fact that fresh pepper is seasonal.

Table 1: Socioeconomic characteristics of fresh pepper marketers

VARIABLES	FREQUENCY	PERCENTAGES
AGE		
Less than 20 years	12	9.6
20-29	18	14.4
30-39	28	22.4
40-49	50	40
50-59	10	8
60 and above	7	5.6
Total	**125**	**100**
Gender		
Male	19	15.2
Female	106	84.8
Total	**125**	**100**
Marital Status		
Single	17	13.6
Married	79	63.2
Widow/divorced	29	23.2
Total	**125**	**100**
Household size		
1-3	31	24.8
4-6	75	60
7-9	19	15.2
10 and above	**-**	-
Total	**125**	**100**
Educational status		
0-6	21	16.8
7-12	87	69.6
13-18	17	13.6
Total	**125**	**100**
Marketing Experience		
1-4	31	24.8
5-9	76	60.8
10 and above	18	14.4
Total	**125**	**100**
Source of Finance		
Personal savings	21	16.8
Commercial bank	-	-
Bank of Agriculture	7	5.6
Friends and relatives	87	69.6
Microfinance Bank	-	-
Cooperatives/Isusu	10	8.0
Total	**125**	**100**
Trade Union		
Member	114	91.2
Non members	11	8.8
Total	**125**	**100**
Other Business actives		
No	96	76.8
Yes	38	23.2
Total	**125**	**100**

Source: Field survey, 2022.

Marketing channel and volume of trade among the channels

Marketing channel refers to the various means to the various path ways through which fresh pepper moves from producers/suppliers till it gets to the consumers. It is the sequence of intermediaries or middlemen and marketers through which produce pass from producers to final consumers Isitor, Otunaiya and Iyanda (2016).The distribution channels of fresh pepper in the study area indicated four marketing channels as shown below. The marketing channels identified were:

Producer/Supplier → Consumer (16%)
Producer/Supplier → wholesaler → Consumer (30%)
Producer/Supplier → Retailer → Consumer (64%)
Producer/Supplier → wholesaler → Retailer → Consumer (15%)

Fresh pepper is cultivated in Abia State and in all South Eastern States in commercial quantity and due to demand gap most marketers result in sourcing the product from Northern part of the Country to serve its teeming customers. The first channel from above indicates that the product flows from the producer/supplier to consumers. This channel recorded (16%) volume of trade in the study area and the consumers prefer this due to price slash because they buy directly from producer/supplier and pay less. The second channel, the supplier sold to wholesalers who sells to the consumers. This channel recorded 30% of the volume of trade in the study area. The third channel recorded the highest percentage of (64%) where the supplier sold to the retailers whose sells directly to the end users. The last channel comprises of wholesaler and retailer before it gets to the end users. The longer the channel the lower the market price accrues to the producer/supplier due to the activities of the middlemen.

Profitability of fresh pepper marketing

The enterprise budgeting analysis was used to estimate the monthly profitability of fresh pepper marketing as shown in Table 2. The analysis revealed that out of the total cost of ₦ 628,257.5 spent by the marketers, purchases constituted (89.39%) while the least expense was interest on loan (2.68%). From the result, purchasing of fresh pepper is the most vital cost/expenses in the enterprise. Also on the interest on loan, it implies that many marketers do not collect loan from Banks to set up this enterprise in the study area as it is viewed as a petty trading in combination of other activities and most times relatives and friends help their own in its establishment as a support.

On enterprise profitability, marketers realized ₦ 833, 495.3 after spending a total variable cost of ₦441, 878.5 and total cost of ₦628, 257.5. The enterprise generated a gross margin of ₦ 391,616.8, net marketing income of ₦205, 237.8 and net return on investment of 0.3266. The implication of the net return on investment is that the marketers return 67 kobo for every 1 Naira invested in the enterprise. The overall profitability indicators (gross margin, net marketing income and net return on investment proved that fresh pepper marketing was a profitable enterprise in the study area.

Table 2 Estimated monthly profitability of fresh pepper marketing

VARIABLE	PARAMETERS	%
Total Revenue	833, 495.3	
VARIABLE COST (VC)		
Purchases	395,017.8	89.39
Transportation	34, 707.7	7.85
Miscellaneous (Recharge card, water, nylon bag,)	12,153	2.75
TOTAL VARIABLE COST (TVC)	441,878.5	100
FIXED COST (FC)		
Monthly shop rent	50,189	26.9
Ground levy	82,190	44.09
Depreciation on equipment (chair, tarpoline,table, bucket, tray)	21,000	11.26
Local government charges	28,000	15.00
Interest on loan	5,000	2.68
TOTAL FIXED COST (TFC)	186,379.00	100
TOTAL COST TC =TVC+TFC	628,257.5	
Gross margin = TR-TVC	391,616.8	
Net marketing income NMI=GM-TFC	205,237.8	
Return on Investment TR/TC	1.32	
Net Return on Investment NMI/TC	0.3266	
Gross Ratio TC/TR	0.753	
Marketing Efficiency TC/TR*100/1	75.37	

Source, Field survey, 2022

Marketing efficiency of fresh pepper marketing

The Shepherd-Futrel technique was used to determine the coefficient of marketing efficiency. The method express marketing efficiency as the ratio of total cost to total revenue expressed as percentage. The lower the percentage, the better the marketing efficiency, since the less proportion of the revenue will be expanded on the total cost of marketing. The result of analysis revealed a market efficiency of 75% implying that the marketers were inefficient in the operation of fresh pepper marketing in the study area.

$$\text{Marketing efficiency ME} = \frac{TC}{TR} \times \frac{100}{1} =$$

$$\frac{628,257.5}{833,495.3} \times \frac{100}{1} = \mathbf{75.37}$$

$$\text{Benefit Cost Ratio (BCR)} = \frac{\sum TR}{\sum TC}$$

If BCR $>$ 1, then the business is profitable

If BCR $<$ 1, the business is running at a risk.

$$= \frac{833,495.3}{628,257.5}$$

= **1.32.** The enterprise is profitable.

Constraints to Fresh pepper marketing

The constraints associated with fresh pepper marketing in the study area were shown in Table 5. The findings show that decay and rioting (Perishability) (3.06) was perceived as the most serious challenge in fresh pepper marketing in the study area. This is in line with Isitor, Otunaiya and Iyanda (2016) who reported spoilage as a major constraint to the enterprise. Other major constraints of relevance to the marketers in the study area were price fluctuation (3.02), Sit-at-home palaver (2.95) and Cough and Catarrh (2.90). Marketers in the study area complained that incessant and irregular Sit-at-home-palaver is affecting their enterprise grossly both in revenue, reduces freshness of the produce due to over stay both in shops and inside the bus for fear of being attacked. There is always price variation in the marketing of fresh pepper in the study area. Marketers in the study area do complain of coughing and runny nose in their discharge of the enterprise. This is as a result of constant inhaling of the fragrance on daily basis. Other constraints in the study area were Irregularity in supply (seasonality) (2.50), Breakage (2.30), pepperish to the body and inappropriate storage facilities

Table 5: Constraints to Fresh pepper marketing

Constraints	Mean score	Rank
Decay and rotting (Perishability)	3.06	1st
Breakage	2.30	6th
Price fluctuation	3.02	2nd
Cough and Catarrh	2.90	4th
Pepperish to the body	2.08	7th
Irregularity in supply (seasonality)	2.50	5th
Sit-at-home palaver	2.95	3rd
Inappropriate storage facilities	2.02	8th

Source, Field Survey, 2022.

Summary

The study examined the economic analysis of fresh pepper marketing in Aba North local government area, Abia State, Nigeria. The study specifically described describe the socioeconomic characteristics of the marketers, marking channel and volume of trade among the channels, profitability and economic efficiency of the marketers and constraints to pepper marketers in the study area.

A multistage sampling procedure involving purposive random sampling methods were used to select 125 marketers.

Finding from socioeconomic characteristics showed that majority of the marketers were within the age bracket of 30 and 49 years and a female dominance (84.8%) in the study area.

The result of marketing channel revealed four channels of which the third channel recorded the highest percentage of (64%) . The result of profitability of fresh pepper marketing showed that out of the total cost of ₦628, 257.5 spent by the marketers, purchases constituted (89.39%) while the least expense was interest on loan (2.68%). From the result, purchasing of fresh pepper is the most vital cost/expenses in the enterprise. The enterprise generated a net return on investment of 0.3266 and the implication of the net return on investment is that the marketers return 67 kobo for every 1 Naira invested in the enterprise. The overall profitability indicators (gross margin, net marketing income and net return on investment proved that fresh pepper marketing was a profitable enterprise in the study area. Findings on constraints militating against fresh pepper marketing showed that decay and rioting (Perishability) (3.06), price fluctuation (3.02), Sit-at-home palaver (2.95) and Cough and Catarrh (2.9) were perceived as the most serious constraints in the enterprise. Other constraints in the study area were Irregularity in supply (seasonality) (2.50), Breakage (2.30), pepperish to the body and inappropriate storage facilities.

CONCLUSION

Fresh pepper marketing in Aba North LGA is a profitable venture given positive values of gross margin, net marketing income and return on investment. The marketers were efficient in the business although inefficiencies still exist due to marketing constraints. The level of profitability can improve if adequate measures are taken by stakeholders to address marketing constraints identified in the study.

RECOMMENDATION

Based on the findings of this study the following recommendations were made:

i. Government and other relevant agencies should assist the marketers of fresh pepper with affordable means of preserving the produce from decay and rioting.
ii. Relevant Stakeholders should address the economic sabotage of sit-at-home palaver which is adversely affecting perishable produce.
iii. Government and Stakeholders should liaise with health expects to find a lasting solution to cough and catarrh associated with constant inhalation of fresh pepper pungent odour.

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Urea Treatment and Ensiling Period Effects on Physico-Chemical Value of Rice Straw and Performance of Kano Brown Buck

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K E Y W O R D S

Ensiling, urea,
Physico-chemical properties,
Rice straw residue

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A B S T R A C T

Feed cost accounts about 50 – 80% of the total cost of animal production and its well-known fact that the shortage of feed in terms of quality and quantity during the dry season remains the, or among the most critical barriers facing animal agriculture in northern Nigeria and beyond. A three- month experiment was conducted at the teaching and research farm of the Department of Animal Health and Husbandry, Audu Bako College of Agriculture Danbatta, to determine the ensiling period effect(14, 28 and 42-day) and urea treatment levels (0%,2%,4% and 6%) on physico-chemical parameters of rice straw residue and its impact on performance of Kano brown bucks. The experiment was laid in a completely randomised designed (CRD) arranged in a 3x4x4 factorial experiment. Four experimental animal groups replicated thrice were offered the experimental diets for a period of 30-day feeding trial. SAS software package was used for the data analysis and least significant difference (LSD) technique was used to separate the means. The results showed that 2% urea inclusion level significantly ($P<0.05$) improved the physical properties(colour, odour, mouldness and temperature) and with regard to the chemical composition, CP content significantly increased at 42-day ensiling period (12.65%) and 6% urea treatment levels (13.18%), yet, the overall finding indicated that 2% urea inclusion levels yielded the best result as reflected in the liveweight gain and its therefore, 2% urea inclusion levels and 28-day ensiling period is recommended and in concluding, the research finding proved that urea above 5% level of inclusion in feed of ruminant is absolutely toxic.

INTRODUCTION

Several researches reveal that an average Nigerian is protein deficient as consumes less than 10g per day against the 35g as the minimum daily protein intake recommended by FAO and WHO, 1997. Animal protein constitutes about 17% of the total protein consumed by an average Nigerian compared to other developed nations with 60% in the United Kingdom, 67% in Denmark, 68% in New Zealand, and 71% in United States of America (World Bank, 2001). According to Ani and Adiegwu (2005), the low protein intake is attributed to the low level of animal protein production leading to high cost of animal products.

However, the high cost of feed ingredients, especially the conventional energy and protein sources like Maize, Soybean meal, Groundnut cake, Fish meal and the like, is the major factor militating against intensive livestock production in Nigeria and beyond (Grace, 2017).

In general, feed is the top most factor militating against the emergence and development of the poultry industry in Nigeria and other developing nations, accounting 50% - 80% of the production cost (Omolayo, 2018; Isaac and Charles, 2018). The ever-increasing trend in human population with a projection of about 10 billion people world population by the year 2050 which is likely to create competition between man and livestock for food (Meissner *et al.*, 2013; Emi, 2019). Likewise, there is rapid growing number of poultry farms and feed compounding mills across the globe (Hassan, 2016). As protein sources, the major conventional feed ingredients are fish meal (animal source) and soybean meal or groundnut cake (plant source) which are expensive (Nana *et al*., 2019).

Both production and demand of livestock will be significantly increase in the near future, from 180 million birds in 2016 to 900 million birds in the poultry population alone in 2050 in Nigeria (FAO, 2019).

METHOGOLOGY

A three- month experiment was conducted at the teaching and research farm of the Department of Animal Health and Husbandry, Audu Bako College of Agriculture Danbatta, to determine the ensiling period effect (14, 28 and 42-day) and urea treatment levels (0%,2%,4% and 6%) on physico-chemical parameters of rice straw residue and its impact on performance of Kano brown bucks. The experiment was laid in a completely randomised designed (CRD) arranged in a 3x4x4 factorial experiment. Four experimental animal groups replicated thrice were offered the experimental diets for a period of 30-day feeding trial. SAS software package was used for the data analysis and least significant difference (LSD) technique was used to separate the means.

RESULTS AND DISCUSSION

Table 1 presents the physical properties of rice straw residue treated with urea. The colour observed at all the inclusive levels of urea and at all the ensiling periods were acceptable colour for good silage (Bates, 1998). The silage colour improvement as ensiling increased was normally as had been observed in colour changes and management in brown colour of maize strover silage from 20 to 50-day. The pungement smell and absence of mould observed in all the urea treated silage indicate the effect of ammoniation (Shan *et al*., 2021).

The strong ammonia smell suggested a higher ammonia concentration in the silages which may have prevented the growth of mould by acting as a fungicide, this is in agreement with the finding of Elseed (2003). This means that urea could be used for long term preservation of rice straw residue residence silages as presence of mould in silage is undesirable as it uses silage nutrients and sometimes, enhanced the production of toxins (Nguyen and Dang, 2020).The temperature range observed in the urea treated silage was similar to the range (25 - 27.5 0C) similar to silage from guinea grass (Babayemi, 2009). Excessive heat production was reported to result in mallard or browsing reactions which can reduce digestibility of protein and fibre component (Bolsen *et al*., 1996).

Table 1. Physical properties of urea treated ensiled rice residue

Parameter	Ensiling period (days)	Urea level (%) 0	2	4	6
Colour	14	Greenish-yellow	Green	Green	Green
	28	Greenish-yellow	Greenish-brown	Greenish-brown	Greenish-brown
	42	Greenish-yellow	Greenish-brown	Greenish-brown	Greenish-brown
Odour	14	Pleasant	Pungent	Pungent	Pungent (strong)
	28	Pleasant	Pungent	Pungent	Pungent (strong)
	42	Pleasant	Pungent	Pungent	Pungent(strong)
Mouldness	14	Slightly mouldy	Absent	Absent	Absent
	28	Slightly mouldy	Absent	Absent	Absent
	42	Slightly mouldy	Absent	Absent	Absent
Temperature (^{0}C)	14	26.00	26.20	26.20	26.15
	28	26.00	26.05	26.30	26.20
	42	26.00	26.05	26.30	26.50

Table 2 shows the ensiling periods and levels of urea. It indicates the chemical composition of rice straw residue at 0%, 2%, 4% and 6% level of inclusion. The chemical components of both fresh and ensiled rice straw residue analysed were dry matter, organic matter, cruid protein, ether extract, ash, neutral detergent fibre, acid detergent fibre and acid detergent lignin. Table 3: presents the dietary treatment effects of the experimental diet on goats as supplement fed at 5% percent body weight.

Table 2. Effect of ensiling period and level of urea treatment on chemical composition of rice straw residue

Parameter	DM	OM	CP	EE	Ash	NDF	ADF	ADL
Fresh	35.02	92.00	6.25	3.00	8.00	70	42.60	14.3
Ensiled (days)								
14	31.36	82.96	11.10	2.18	7.04	96.61	38.26	12.49
28	29.64	92.67	11.58	2.08	7.33	68.20	38.09	12.12
42	29.80	91.94	12.65	2.18	8.06	65.37	36.50	11.41
SEM	0.32	0.26	0.60	0.11	0.26	0.67	0.74	0.31
Urea level (%)								
0	31.09	93.84	7.71	2.13	6.16	69.50	40.76	13.04
2	30.52	92.00	12.43	2.28	8.00	65.27	34.78	10.83
4	29.49	92.03	12.93	2.18	7.97	67.60	37.56	12.24
6	28.84	92.22	13.18	1.98	7.78	68.53	38.03	11.90
SEM	0.38	0.22	0.21	0.11	0.22	0.80	0.55	0.28

Table 3: Performance of Kano brown bucks fed urea treated ensiled rice straw residue (30-day feeding trial)

Urea level (%)	Initial body weight(Kg)	Final body weight(Kg)	Weight gain(Kg)
0	30.0	32.0	2.0
2	32.0	37.0	5.0
4	31.0	34.0	3.0
6	32.6	34.8	2.2
SEM	0.48	1.03	0.7

SEM – Standard error of mean

CONCLUSION

As stated earlier, the results showed that 2% urea inclusion level significantly ($P<0.05$) improved the physical properties(colour, odour, mouldness and temperature) and with regard to the chemical composition, CP content significantly increased at 42-day ensiling period (12.65%) and 6% urea treatment levels (13.18%), yet, the overall finding indicated that 2% urea inclusion levels yielded the best result as reflected in the liveweight gain and its therefore, 2% urea inclusion levels and 28-day ensiling period is recommended and in concluding, the research finding proved that urea above 5% level of inclusion in feed of ruminant is absolutely toxic.

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Grazing Behaviours of four Nigerian Breeds of Cattle in Awka, South East Nigeria

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K E Y W O R D S

Bite rate,
Breeds' difference,
Grazing,
Grazing pattern,
Grazing time,
Resting position

* C O R R E S P O N D I N G A U T H O R

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A B S T R A C T

This study was carried out to evaluate the grazing behavior (GB) of four different breeds of cattle (Sokoto Gudali, Red Bororo, Adamawa Gudali, and White Fulani) in Awka, South East Nigeria. The study lasted for 90 days from September-December. Twenty four long weaners (average weight of 83kgs) were randomly allotted to four treatments (breeds) with six animals per treatment. The animals were subjected to rotational grazing system, co-grazed more than 6 ha of range containing grass, legumes and browse plants, the vegetative survey showed an average vegetation height of 2.6cm to 10cm. There was periodic recording of time spent Grazing, resting, bite rate and idle position from all the animals . The result show no significant difference (P>0.05) in the bite rate among the four breeds of cattle, but the highest bite rate was recorded in Red Bororo 3.42 (bite/min). The highest resting time was recorded in Sokoto Gudali 48.08(mins) which is not significantly different (P>0.05) from White Fulani 45.00(mins) and the least resting time was recorded in Adamawa Gudali 35.50(min) which was not significantly different from Red Bororo 39.42(mins). There was no significant different (P>0.05) in grazing time among the breeds. The study further revealed average grazing time of 8:26(hrs) and resting time which ranges from 48:00 - 35:00 minutes among the four breeds. There was no significant difference in the rest position among the breeds which show laying as predominant resting position against standing. the study show that the breeds do not differ on their grazing behavior which disagree with previous works showing breed factor as sources of variation on Grazing behavior among different breeds of indigenous cattle.

INTRODUCTION

Grazing behavior is a feeding pattern within the ecology of herbivores which is related to how live-stocks respond in-other to meet their nutritional requirement (Launchbaugh, 2020). Grazing involves the activities of searching, selecting, harvesting and ingesting of forage. This behavioral patterns have been shown to be affected by both abiotic and biotic factors, physiological state of the grazing animal, geographical conditions, sward surface-height, stocking density, and botanical composition of pastures, and breed factor known as trait (Launchbaugh, 2020). Herbivorous or grazing animals differ in the way they grasp and ingest forages (Schulze *et al*., 2019). Abubakar *et al*., (2020) stated that cattle prefer low grassland due to the presence of up dental pad which causes a lack of selectivity and results in cattle eating more dead material than other ruminants, such as sheep, goats. Generally, feed consumption has a reverse relation with temperature and during normal circumstances, an increase in temperature causes lower feed consumption (Rhoads *et al*., 2009). Basic feeding/grazing activities of cattle involves ruminating, resting phase and grazing. Russell, (2001) in his work on the grazing pattern of cattle stated that cattle normally spent about 45 minutes in each period of resting and ruminating. According to Van Laer *et al*., (2015), both individual (phenotypes or genotypes) and group (breeds) diversity can impose different grazing patterns. Also vegetative composition and availability is directly proportional to time spent grazing as scarcity of forage will increase the time spent grazing and the availability will reduce the time spent grazing. Further more, studies on grazing behavior are baseline information for designing improved grazing management schemes that will ameliorate animal productivity, welfare and increase grassland diversity (Utsumi *et al*., 2009; Lin *et al*., 2011; Meier *et al*., 2012). Various grazing management systems and restoration strategies have been employed for ecosystem maintenance and sustainable utilization of range-lands for livestock production (Havstad *et al*., 2007) they include; Rotational grazing, use of enclosure, season grazing, and this strategy has no doubt shown a positive attribute towards gain and welfare of cattle. Some indigenous cattle breed have shown high level of adaptability and performance under aforementioned management system; The White Fulani cattle, Muturu, and Gudali breeds are, however, important for their genetic predisposition of hardiness, heat tolerance and adaptation to local conditions (Alphonsus *et al*., 2012)

In Nigeria over the past decade; drought, poor knowledge on grazing behavior and Government policy (open grazing law 2017) have resulted to farmer-pastoralist conflict which has escalated in recent years and are spreading throughout the nation, threatening the country security and stability. International crisis Group reported an estimated death toll of approximately 2,500 people in 2016. There is need to establish core information on patterns of grazing in other to mitigate the effect of inadequate availability of forages from the natural pasture for sustainable livestock production in Nigeria (Jacobo *et al*., 2006). However, in other to provide solution towards the ongoing conflict among cattle headers and farmers in southern Nigeria, and to mitigate the negative effect of extensive grazing in eco system, there is need to understand the grazing patterns of common breeds of cattle which in return will provide core knowledge in developing management strategies which will not have adverse effect on the welfare and decrease their negative effect of overgrazing in the eco system particularly in our nation Nigeria.

MATERIALS AND METHODS

The study was carried out at Nnamdi Azikiwe University Awka Anambra state Nigeria. Awka is the capital of Anambra state with mean annual temperature, rainfall and humidity of 27.0˚C, 1828mm and 80% respectively. The peak of rain fall is September having an average rainfall of 306mm and least is December with a rainfall of 7mm, annual rainy interval last for about six months. It is located within the latitude of 60˚12 25" N and longitude of 7˚04 o4" E.

Vegetation

The vegetative components of the field was evenly distributed. The botanical composition of the grazing field was classified 95 percent of grass, legume, herb, (mostly: *Panicum maximum, Centrosoma pubescence* etc.) and 5 percent browse plants. The animals were placed on rotational grazing system, also the demarcated section of the farm was used for the experiment, botanical survey was carried out on the vegetation using qua-drat frame the result showed an average vegetative height which ranges from 2.6-10cm.

Management

Total number of twenty-four intact male long weaners comprising of 6 animals each from different breeds (Sokoto Gudali, Red Bororo, Adamawa Gudali, and White Fulani) of cattle were procured from cattle markets in Adamawa. The study lasted for 90 days, using 6 growing animals per breed. Animals was subjected to rotational grazing system, co-grazed more than 6 ha of range containing grass, legumes and browse species, grazing record was taken on all the experimental subject periodically from 0800-1700. Before the onset of the study, all the experimental animals were dewormed and administered Oxytetracycline L.A. They also were ear tagged for proper identification. The research was undertaken during (September- December). During the observation period, supplement of concentrated palm kernel cake and poultry dropping was provided once a day mostly in the morning. The animals have an average weight of 85kgs.

Data collection

The primary (grazing, resting time) and secondary (bite per minute, idle phase) behavioral patterns were assessed without block and replicate. The animal were observed at a distance of about 10 meters in other to avoid altering the record. All animals were followed on pasture for the whole days and records taken per animal at a given period of time.

Grazing time: The experimental cattle were carefully monitored and followed during grazing to estimate the grazing time. The animals were grazed from 0800 – 1700 hrs. The length of grazing was recorded by the use of stop watch.

Bite rate: Measurements were taken periodically throughout the experiment. Bite rate (bite/ min) was calculated by recording the number of bites in five minutes period among the four different breeds of cattle.

Resting time and position: Idling phase was frequently observed during the period of the project (standing and lying) by recording the time spent on each position during resting.

Experimental Design. The experimental design was a one way classification in completely randomized design (CRD).

Data collected was analyzed using one-way analysis of variance (ANOVA) using (SPSS) model 2011, When the analysis of variance revealed significant differences, treatment means were compared using Least Significant Difference (LSD) test ($P<0.05$).

RESULTS AND DISCUSSION

The study revealed that there was no significant difference among the four breeds in their grazing time with average grazing time of 8:14 to 8.29h a day representing 92% of their day light activities (Table 1). The current result agrees with the reports of (Lyons and Machen;2000, Viator *et al*., 2013) who stated that cattle to spent 7 to 12 h a day grazing; which occupy about 70-90% of daylight activities. Time spent for grazing by herbivores primarily depends on supply of feed from the grazing area (Viator *et al*., 2013). Less time is spent grazing when forage is plentiful and quality is good, and vice versa. The findings support the previous report of (Mohammed *et al*., 2020) who reported no significant difference in grazing time among breeds of cattle which spent 83% of the day light activities grazing . Ferreira *et al*. (2013) also noted that due to the nature of the teeth, cattle are reluctant to modify diet preferences towards browse vegetation species if sward height is not below 4 cm. In this study, sward height was between the range of 2.6-10cm, forage patch condition, could presumably be a reason for cattle spending almost the 89% of day light activities grazing. Breinhort *et al*., (2000) studied the influence of animal factor on day and night grazing activity of imported Holstein-Friesian cow his mean grazing activity accounted for 7.6 hours at night and day light activity of 7.4 hours per 24 hours, contradiction from this findings may be as a result of less level of adaptability from the exotic breed used and also difference in weather condition of the research area.

Generally, the time spent during day light for resting was not affected by the co-grazing animal breeds in this study. It appeared that animals were busy harvesting forages to meet nutritional requirements during the 9 h day light that they were allowed to stay in the grazing area. Accordingly, time spent for resting might have happened during night time (Fierro and Bryant, 1990: Moges and Uden, 2005), with possible differences among the co-grazing animal these different breeds. From this study the resting time occupy 9% of their daylight activities. The result from these study on resting behavior contradict to the time estimated by Braun *et al*. (2013), who calculated resting time in cattle at a mean of 16.2 min/ 5h with a range from 11.6 to 18.6 min/h, which is a result of less grazing time given by his trial. Similar results to those reported in the current study for rumination and resting time are those of Gregorini *et al*. (2012), reported that the resting and rumination in cattle mostly occurring during the night with an average rumination and resting time estimated from 18 to 25 min/h. however; since resting time is subjected to be voluntary control by the animals the grazing cattle might regulate resting time in an attempt to increase or reduce digesta flow from the rumen (Chilibroste *et al*., 1997). In the study of Hassoun (2002) the patterns of feeding, resting and grazing time were also similar to the findings of the present experiment.

Furthermore Udeh *et al*., (2013) stated a significant difference among Muturu and Sokoto gudali on the total grazing record which contradict the findings of this study. Muturu is highly adapted breed in southern part of Nigerian while Sokoto gudali in northern part of Nigeria, his experiment was undertaken in south east of the country recalling that grazing behavior can be acquired (Baily *et al*., 2015) and has been repeatedly reported to be affected by geographical condition . Also Jennifer *et al*., (2014) sated that low level of adaptability by exotic breeds resulted to different on grazing behaviour among local and exotic breeds.

The mobile tongue and large and flat muzzle of cattle makes them less efficient in short swards and browses (Mohammed *et al*., 2020). The result from this work show that Red Bororo have the highest bite rate which do not differ significantly from the other breeds. Sprinkle *et al*., (2020) on his study on grazing behavior and production characteristics among cows support this research work by his statement of 18.5 mins on each phase of ruminating which no significant difference among different breeds of cattle. Jacobo *et al*., (2006) classified cattle as slow eaters which is mostly affected by vegetative characteristics.

Table .1: Grazing behavior of different breeds of cattle

Parameters	Bite Rate (Bite/min)	Resting Time (mins)	Grazing Time (hrs)	Position (laying/standing)
Sokoto Gudali	3.32	48.67	8.14	standing
White Fulani	3.17	45.00	39.17	Laying
Red Bororo	3.42	39.17	8.23	Laying
Adamawa Gudali	3.20	35.50	8.21	Lying
SEM	0.11	1.69	0.02	
P-Value	0.87	0.02	0.52	

Note; ($P<0.05$); SEM: Standard Error of Mean.

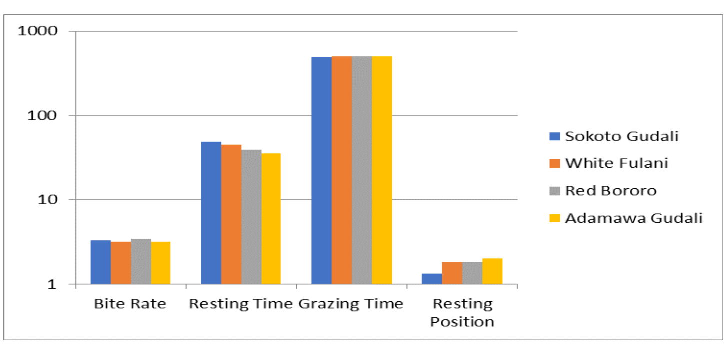

Figure 1: Bar chart: Grazing behavior of different breeds of cattle

CONCLUSION

The study on grazing behavior of four different breeds of cattle (Adamawa gudali, Sokoto gudali, white Fulani, Red Bororo) show that those breeds do not differ on their grazing behavior. The study further revealed the average grazing time to be 8:26h. This disagrees with other findings that grazing behavior vary among different breeds of cattle when subjected to same management practices.

RECOMMENDATION

This research brings new insights into the grazing cattle daily time budgeted in Awka south east Nigeria in respect to grazing time, bite rate (intake rate), idle position and resting time for developing management strategies. Cattle should be allowed to graze at minimum of 8h/day. From this study Sokoto Gudali breed of cattle was least adapted on this geographical region compare to other breeds.

Further study of both daylight and night grazing behaviors using digital monitoring devices might be needed to have a better insight on the impact of co-grazing of different livestock breed on range and productivity.

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The Role of Irish Potato Farmers of the Women-in-Agriculture and Youth Empowerment (WAYE) Programme in Plateau State, Nigeria

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K E Y W O R D S

Irish Potatoes
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WAYE
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A B S T R A C T

The study focused on the role of Irish potato farmers of the Women-in-Agriculture and -Youth Empowerment (WAYE) programme in Plateau State, Nigeria. A multi-stage sampling method was employed to select 256 respondents. Primary data were collected through the use of questionnaires and were subjected to both descriptive and inferential statistics. The mean farming experience was 10 and 16 years for participating and non-participating farmers while mean farm size for participating farmers and non-participating farmers was 1.4 and 0.5 ha. The result of the findings reveals that, (55%) and (47%) of the participating farmers and non-participating farmers had secondary school education, which constituted the largest number of educational qualification attained in the study area. Factors influencing the level of participation of Irish potato farmers in WAYE programme in Plateau State are, marital status (3.72, $P<0.01$), sex (2.25, $P<0.05$), years of Irish potatoes production (9.85, $P<0.01$), household size (10.92, $P< 0.01$), awareness of WAYE programme (4.93, $P< 0.01$), a unit increase in these factors will subsequently influence the level of participation of Irish potato farmers in WAYE programme. The mean crops output of WAYE programme participants (537,807.1kg) was significantly higher than non-participants (165,571.43kg). The difference in the mean crops output levels was largely attributed to participation in WAYE programme. The calculated Z-test value (14.74) for crops output and income (22.93) was significant at 1% probability level. It was therefore recommended that WAYE programme be extended to other farming communities in Plateau State, so as to accelerate the poverty alleviation among women farmers in the State

INTRODUCTION

Irish potato (*Solanum tubersun*) belongs to the solanaceae family, it is a native of western hemisphere and is believed to have originated somewhere between Mexico and Chile possibly in Andes highlands of Bolivia and Peru. It later spread to other places like England and Ireland where it is predominantly cultivated Irish potato was introduced into Nigeria in the later part of the 19th century and early 20th century by Europeans notably the Tin miners in the Jos Plateau (Mado, 2013). It has a high nutritive value and it is grown for food purposes as well as livestock feed. It is also used for industrial purposes (Okeowo, 1999; Burton, 2000. Irish potato is therefore an important crop not only as food crop, but also its social, economic and environmental relationships with the people who grow, sell and consume it (Alimba and Mgbada, 2003). The empowerment of women and youths that are involved in potato production in Plateau State is therefore crucial to poverty reduction. Women-in-Agriculture and Youth Empowerment (WAYE) programme aims at encouraging Irish potato production through participation of the target group as a strategy to combat rural poverty. Therefore, Women-In-Agriculture Programme (WIA) and Youth-In-Agriculture Programme (YIAP) were both initiated and implemented towards reducing poverty, improvement on the income and raising the level of living of rural dwellers to achieve the first goal of the MDGs (Sharma, 2004).

A number of studies have been carried out by different scholars (Shittu, 2012; Kotter and Petras, 2012; Mado, 2013; Shittu and Panan, 2014) to assess the Women-In-Agriculture and Youth Empowerment (WAYE) programme. Their focus, however, was on women and men and only few Local Government Areas were covered, thus limiting the scope on WAYE programme objectives. Similarly, Ifenkwe (2015), in his study on the impact of WAYE programme, concentrated his efforts more on reproductive health (HIV/AIDS and rehabilitation) while the agricultural component and other aspects of the programme were greatly ignored. What is almost lacking in these studies, however, is any direct involvement of youth in the programme and assessment of role of the programme on the livelihood of the participating farmers. Therefore, their studies have left a knowledge gap on role of Women-In-Agriculture and Youth Empowerment programme objectives. Furthermore, these studies are empirically shallow in their analysis and left much to be desired as reliable sources of information to develop specific theories of programmes to alleviate rural poverty and improvement on the livelihood of the rural farmers. This has indeed created knowledge or information gap in the literature. It is based on this, that the study, therefore, intended to provide empirical analysis on women and youth that will be useful for re-assessment and re-orientation of the program's objectives and focus. And thus, the study would make an attempt to find solutions to the objective: The role of women-in-agriculture and youth empowerment (WAYE)program me among irish potato farmers in Plateau State.,the specific objectives are to: describes the socio-economic characteristics of Irish potato farmers in the study area; determine the factors influencing the Irish potato farmers' participation in the WAYE programme and examine the effect of Women-In-Agriculture and Youth Empowerment(WAYE) programme on crop output and income of farmers;.

METHODOLOGY

This study was conducted in Plateau State, Nigeria. The State was created in 1976 from the defunct Benue-Plateau State. The name "Plateau State" was derived from the State's spectacular geographical landscape, with the high lands rising from 1,200 meters above sea level at the low lands to a peak of 1,829 meters above sea level. It is located in Nigeria's middle belt and lies between latitude $80.24^0\ N$ and longitudes $80.32^0\ E$ and $100.38^0\ E$ ofthe Greenwich Meridian. The State is situated in the tropical zone, with a higher altitude ranges from 12 meters, about 400 feet to a peak of 1829 meters above sea level (Plateau Agricultural Development Programme, 2000). Plateau State has a boundary with Bauchi State to the north-east and Kaduna State to the north-west. It is also bounded to the south-east and south-west by Taraba and Nasarawa States, respectively. The State has a landmass covering nearly 53,585 square kilometers with a population of 3,577, 669 people as per 2006 census (NPC, 2006).

A multi-stage sampling procedure was used to select participating farmers for the study. There are nine (9) Irish potatoes producing Local Government Area in Plateau State and they are given a priority consideration for the programme. In the first stage, all these nine Local Government Areas were used for the study. This was because of their high level of production of potatoes in State. In the second stage, two villages were randomly selected in each Local Government Area and this was based on the level of participation in the programme as well as in potato production. This gave a total of eighteen (18) villages. During a reconnaissance survey of the study area in 2016, the list of WAYE potato farmers in the chosen villages was compiled with the help of the programme coordinating officers in each LGA and the total number obtained was 711 farmers. Therefore, a total number of 256 Irish potato farmers were selected randomly using the random number table method.

Both primary data and secondary information was used for the study. The primary data were obtained by the use of well-structured questionnaire and administered to the participating farmers and non-participating farmers by the researcher and to be assisted by well-trained enumerators from the Plateau State Agricultural Development Project (PADPs). The secondary information was obtained as base-line information from WAYE head office and the coordinating liaison offices. Also, information from other related studies were used to support the discussion of results of the findings. Data were analyzed using both descriptive and inferential statistics. Descriptive statistics was used describe the socio-economic characteristics of participants in the programme and Inferential statistics was used to achieve and determine the factors influencing the Irish potato farmers' participation in the WAYE programme. Z-test) was used to assess the effect of Women-In-Agriculture and Youth Empowerment(WAYE) programme on crop output and income of farmers;)

RESULTS AND DISCUSSION

Socio-economic Characteristics of Participating and Non-Participating Farmers

The result in Table 1 shows that the mean age of the participating farmers was 38 years while that of the non-participating farmers was 43 years. This means that the participating farmers were younger in age than the non-participating farmers. This is in line with the major objective of WAYE programme to engage both young men and women in agricultural activities with the aim of improving the living conditions of households in the study area. Age has been found to be an important variable in agricultural productivity; hence both categories of the farmers were within the agricultural productive age range of 30-50 years quoted by Food and Agriculture Organization (FAO, 2000; 2008). About 65% and 60% of the participating farmers were married and single while (66%) and (17%) of the non-participating farmers were also married and single respectively. The significance of marital status on agricultural production can be best explained in terms of the supply of family labour (Adewale, 2005).

The result of the study shows, that (67%) and (33%) of the participating farmers were males and females while (77%) and (33%) of the non-participating farmers were males and females respectively. This agrees with the findings of Ayandiji and Adeniyi (2011) who reported that males have dominance potato production activities unlike their female's counterparts because agricultural activities are regarded as labour intensive. The result in Table 1 indicated that majority (63%) of the participating farmers cultivated between 1-1.5ha for Irish potato production while (75%) of non-participating farmers used less than 1ha.This mean farm size cultivated by both categories of farmers was 1.4 ha and 0.5ha respectively. According to Adamu (2019) classification of farm size of 0.1 - 5.9 hectares as small farms implies in this study that all the farmers were small scale farmers. This may be due to the inheritance system of land ownership practices in the study area which results in land fragmentation among farmers, leading to small farm holdings. The implication of small farm size affects the quantities of Irish potato output produced which in turn affect both the income and food security status of the farmers. The result agrees with the finding of (Nwosu, 2007) who reported that majority (82%) of the farmers acquired the farmland through renting with farm sizes ranging from 0.5-4 hetares. Farming experience in Irish potato, the result in Table 1 indicated that, (67%) and (54%) of both the participating farmers and non-participating farmers had Irish potato farming experience between 1-10 years and 11-20years respectively. Abonge (2012) opined that farming experience is an important factor in determining both the productivity and the production level in farming.

The result in Table 1 reveals that (55%) and (47%) of the participating farmers and non-participating farmers had secondary school education, which constituted the largest number of educational qualification attained in the study area. Adewale(2005) had identified literacy among other factors as a variable that positively influenced the use of improved agricultural inputs by farmers. According to the distribution of respondents in Table 5.1. The result shows that majority (77%) and (73%) of the participating and non-participating farmers have a family size of 1-10 members respectively. This finding agrees with that of Ifenkwe (2012) reported that the average family size in Africa is between 8 and 9 people in a household. The implication of large number in a household can be a motivation to the adoption of innovations because members will provide the required family labour for Irish potato production. This will reduce the cost of production.

Table 1: Distribution of respondents according to age, marital status, Gender, farm size, farm experience, educational level and household size.

	Participating farmers		**Non – participating farmers**	
	Frequency	Percentage	Frequency	Percentage
Age(Yrs)				
20 – 30	17	6.64	8	3.13
31 – 40	173	67.57	96	37.50
41 – 50	56	21.88	118	46.09
51 – 60	8	3.13	23	8.98
61 – 70	2	0.78	11	4.30
Total	256	100	256	100
Mean	38		43	
Marital status				
Single	60	23.44	43	16.80
Married	166	64.84	169	67.58
Divorced	8	3.13	11	4.30
Widow	22	8.59	33	12.89
Total	256		256	100
Gender				
Male	171	66.80	196	76.56
Female	85	33.20	60	23.44
Total	256	100	256	100
Farm size(ha)				
Less than 1	36	14.06	192	75.2
1 – 1.5	162	63.28	35	13.68
1.6 – 2.5	47	18.36	21	8.20
2.6 – 3.5	8	3.13	7	2.73
3.6 and above	3	1.17	1	0.37
Total	256	100	256	100
Mean	1.4		0.5	
Farming exp(yrs)				
1 – 10	172	67.19	72	28.13
11 – 20	64	25.00	138	53.91
21 – 30	14	5.46	26	10.16
31 – 40	5	1.95	14	5.46
41 – 50	1	0.40	6	2.34
Total	256	100	256	100
Mean	10		16	
Educational level				
No education	10	3.91	6	2.34
Qur'anic/adult.	7	2.73	11	4.30
Primary	71	27.73	88	34.38
Secondary	141	55.08	120	46.88
Tertiary	27	10.55	31	12.10
Total	256	100	256	100
Household size				
1 – 10	198	77.34	187	73.05
11 – 20	55	21.48	64	25.00
21 – 30	3	1.18	5	1.95
Total	256	100	256	100
Mean	8		8	

Source: Field Survey, 2017

To examines the factors influencing level of participation in WAYE in Plateau State. The results in Table 5 indicate that, commutatively about 17.6% of the variation in level of participation is explained by the variable included in the model. It shows that marital status, years in Irish potatoes production, household size, awareness of WAYE were found to significantly influenced the level of participation at 1%, level of probability whereas only sex, is found significantly influence the level of participation at P<0.05. The implication of this finding is that, the level of participation increases by variation in marital status thus as farmers' marital status changes from single to married, the level of participation equally increases from 1 to 27.6%. It was also observed that as years in Irish potatoes production increase by 1unit, the level of participation increases by 34.7%. Thus more experience farmers tend to participate more than new in-experienced farmers. So also as household size increase by 1 person the level of participation increase by 78%. Nonetheless as level of awareness of the existence of WAYE programme increases by 1 the level of participation is equally increases by 30%. Based on these findings marital status, sex, years in irish potatoe production, household size, and awareness are the major factors influencing farmers' participation in WAYEP. Adamu (2021), factors influencing women farmers' participation in Development Exchange Centre (DEC) micro credit programme of Kaduna State, Nigeria; shows that level of education (1%), age (1%), house size (5%), credit (10%), farm experience (10%), extension (5%) and years of involvement in cooperative society (5%) were significantly related with level of participation in (DEC) micro credit programme.

Table 5: Estimates Factors influencing farmers' level of participation in WAYE

Variables	Coefficients	Std.Err.	T-value	P>|t|
Livelihood index	0.2763	0.1769	1.56	0.119
Age	14.4942	0.9059	12.82	16.388
Marital status	0.6472***	0.1738	3.72***	0.000
Sex	1.1465**	0.5099	2.25**	0.025
Farm size	0.1742	0.3384	0.51	0.607
Years in iris potatoes production	0.3474***	0.0353	9.85***	0.000
Household Size	0.7805***	0.0715	10.92***	0.000
Credited amount	0.0000	0.0000	0.13	0.897
Profit	0.0000	0.0000	-1.59	0.112
Perception	-0.7914	0.7003	-1.13	0.259
Awareness of wayep	3.0301***	0.6150	4.93***	0.000
_cons	21.2049	3.5333	6***	0.000

Source: Field Survey, 2017 *** P< 0.01, ** P<0.05 and * P<0.10

Effect of Women-In-Agriculture and Youth Empowerment(WAYE) programme on crop output and income of farmers;

The results in Table 6 shows, the calculated Z-statistic was 14.7;and at 0.01 level of significant, the critical table value of Z was ±1.96. Since the calculated Z-value (14.7) is greater than the Z-critical or Z- tabulated value, it implied that there was significant difference in the mean crops output level of WAYE programme participants, and non-participants. Also the estimated mean crops output of participants was much higher than that of non-participants, (537,807.1kg) as against (165,571.43kg), as indicated in Table 3. Hence WAYE programme participants declared a higher level of output from their crops output than non-participants. Hence, the impressive difference in the farmers mean crops output levels were largely attributable to farmers' access to WAYE programme. The calculated Z-statistic value for income was 24.19 but at 0.01 level of significance, the critical or table value of Z is ±1.96. Since the calculated Z-value (24.19) was greater than Z-tabulated, it implied that there is significant difference in the mean income of WAYE programme participants and non-participants. Also the estimated mean income of beneficiaries (₦749,379.50) was discovered to be much higher than the estimated mean income of non-beneficiaries (₦234,222.20). Hence, the WAYE programme participants had higher mean income from their irish potato production than non- participants. Therefore, the findings confirmed that the impressive difference (₦515,154.30) in the mean income of WAYE programme participants from non-participants might largely be attributable to their access to WAYE programme.

Table 6: Examine effect of Women-In-Agriculture and Youth Empowerment(WAYE) programme on crop output and income of farmers;

Variable	Participants	Non- participants
Sample size	256	256
Output(t/ha)		
Mean of crops output	537,807.1kg	165,571.43kg
Standard error of crops output	18960.71	5773.787
Z-calculated	14.7	
Z-critical	1.96	
Income (₦)		
Mean of farm income(₦)	₦749,379.50	₦234,222.20
Standard error of farm income	17295.14	7773.23
Z-calculated	24.19	
Z-critical	1.96	

Source: Field Survey, 2020

CONCLUSION AND RECOMMENDATION

Based on the empirical evidence emanating from both descriptive and inferential statistics employed in the analysis of the role of Irish potato farmers of the Women-in-Agriculture and -Youth Empowerment (WAYE) programme in Plateau State, Nigeria. It has been observed that, loan provided to Irish potato farmers are of short duration with repayment period of less than one year. Majority of the farmers relied on waye programme and were able to obtain ₦876, 000 and above which they are required to repay between 6 to 12 months. WAYE programme is a tool that could be used to improve on the income and crop outputs of irish potato farmers and thus empowers them for a better living. It is therefore recommended that WAYE programme be extended to other farming communities

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Assessment of two Biofertilizers under two Crop Combination on Microbial Population and Plant Growth in South Eastern Nigeria

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K E Y W O R D S

Biofertilizers
Biomass production
Microbial population
Moringa
Tomato

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A B S T R A C T

Biofertilizers are becoming increasingly popular in many countries and for many crops, but very few studies on their microbial population and early plant growth in sandy loam soil have been conducted. Therefore, this research evaluated two different biofertilizers: treated Ageratum specie and Crotoloria specie in the Soil Science Department Chukwuemeka Odumegwu Ojukwu University, Igbariam Anambra State, Nigeria during 2016 cropping seasons in the growth chamber of the Faculty of Agriculture, using two different test crops (Moringa and Tomato) which was laid out in complete randomized block (CRD). The experiments were conducted in pots with dimension of 17cm × 19cm in length and depth. The bottoms portions of the pots were uniformly perforated for proper aeration. Ten seeds were planted after which they were thinned down to 8 seedlings 10 DAP, later, the remaining 2seedlings were harvested 60 DAP to evaluate the biomass production in each stage respectively. Significant biomass and soil microbial population increase due to biofertilizer use were observed in all experimental treatments. The biofertilizer effect on Moringa and tomato growth did not significantly differ. Nevertheless, positive effects of the biofertilizers occurred on the biological properties. However, the trends in these results seem to indicate that biofertilizers might be most helpful in rainfed environments. However, for use in these target environments, biofertilizers need to be evaluated under conditions with abiotic stresses typical of such systems such as drought, soil acidity, or low soil fertility.

INTRODUCTION

Biofertilizer is defined as products containing active or latent strains of soil microorganisms, either bacteria alone or in combination with algae or fungi that increase the plant availability and uptake of mineral nutrients (Vessey, 2003). Bio-fertilizers enrich the soil with diverse, favorable and agronomical relevant microbes and invertebrates and direct the activities of plant roots, and soil organisms to a favorable ecological harmony. All these functions are inter-related, Kohnke (1986). One of the most important contributions of bio-fertilizers to soil conservation and sustainable soil fertility and the ability to detoxify the soil and protect plant roots. In Senegal, Burgo-Leon *et al.,* (1980) reported the incidence of phytotoxicity caused by the exudates of the growing sorghum roots from the flowering stage onwards. The toxicant inhibited germination and seedling establishment of subsequent crops in the field. It was finally discovered that it was the bio-fertilizer flora among which were; *Entrobacter cloacae, Trichodermaviride* and *Aspergillus spp* which bio-degraded the toxicant and restored the soil productive capability. *Entrobacter cloacae* additionally mediate high nitrogen fixation and production of rooting hormone and realized about a 3-fold increase crop yield. Another spectacular event illustrated the ability of certain bio-fertilizer to detoxify petroleum polluted soil and upgrade its fertility status. Mba (1999) highlighted the bio-detoxification of petroleum polluted soil. The pollutant impaired soil phosphorus availability, inhibited germination of sorghum and soya bean and their seedling establishment and furthermore rendered them vulnerable to serious fungal disease. Application of bio-fertilizer detoxify, eliminated the incidence of fungal disease and mediated a 2 – 5 fold increase in soil phosphorus availability (Mba,1999). The constraints may be environmental, technological, infrastructural, financial, human resources, lack of awareness quality, marketing, etc.

The other alternative method of providing nutrients for plant growth and yield is use of soil microbes, which have been proved to be advantageous (Adesemoye *et al*., 2008; 2009a, b; Berg, 2009). There are a wide range of microbes in the soil, which are able to act in symbiosis or non-symbiosis association with their host plant (Gray and Smith, 2005).

Furthermore, the environmental issues regarding the use of chemical fertilization is also of significance as excess amount of chemical fertilization results in the pollution of the environment. Chemical fertilization can also decrease the enzyme activities of soil microbes, soil pH, and soil structure (Bohme and Bohme, 2006). It is therefore pertinent to apply the optimum amounts of fertilization in the field. Accordingly, it can be favorable that other methods of fertilization be also tested and used to provide necessary nutrients for plant growth and yield production, while keeping the soil structure in good shape and the environment clean.

The excess uses of chemical fertilizers in agriculture is costly with adverse effects on soil properties. Therefore, in the recent years several organic fertilizers have been introduced that act as natural stimulators for plant growth and development (Khan *et al*., 2009). The knowledge of such natural stimulator or microbial inocula has long history which started with culture of small scale compost and passes from generation to generation of farmers (Abdul Halim, 2009). These are used for application of seed, soil or composting areas with the objective to enhance the numbers of such microorganisms and accelerate certain microbial process to augment the extent of the availability of nutrients in a form which can assimilated by plant (Khosro and Yousef, 2012). Such biofertilizers are important components of integrated nutrients management in soil, which play key role in productivity and sustainability of soil. With every passing days, these biofertilizer are replacing chemical fertilizers due to cost effectiveness, ecofriendliness and renewable source of plant nutrients. One of the most important effects of compost use is the promotion of soil biology.

The main objective of the study is to assess the effect of two biofertilizers under two crop combination on microbial population and early plant growth in south eastern Nigeria.

Specific objectives of the study are to:

- Evaluate the effect of two Biofertilizers: treated *Ageratum spp*. and *Crotolaria spp.* on early plant growth of moringa and tomato.
- Evaluate the effect of two Biofertilizer: treated *Ageratum spp*. and *Crotolaria spp.* on microbial population.

MATERIALS AND METHODS

Site Description

Soil samples for the planting were collected beside Faculty of Agricultural building complex of Chukwuemeka Odumegwu Ojukwu University, Igbariam Campus at the depth of 5cm – 15cm with augur, the soil was sieved thoroughly to remove unwanted materials. The vegetation ranges from light rain forest to savanna. Dense vegetional cover with high trees is prominent around stream and the shaley lowlands while savanna vegetation and isolated trees are prominent on sandy highland. Anambra State is located at latitude 5°40' and 6°46'N, longitude 6°40' and 7°20E. The annual rainfall of the area varies from 1800mm to about 2500mm, the temperature of the area vary from 21° to over 25° while relative humidity is from 60% to over 85%. The soil sample collected was taken to the Soil Science Department of Chukwuemeka Odumegwu Ojukwu University, where it was used for experiment.

Treatment Arrangement and Allocation

Ageratum conyzoides and *Crotolaria retusa* was harvested green and freshly, chopped into pieces, mixed with fresh pig dropping at 50:50 weight – weight incubated for 2weeks, after which the compost was aerated for 3 – 4 days. Four kilograms of the sieved subsoil was weighed out in 36 buckets. The dimension of the pot is 17cm × 19cm in length and depth. The bottom side of the pots were uniformly perforated to allow adequate aeration and drainage. The weighed soil was thoroughly mixed with 350g of treated bio-fertilizer and watered with 500ml of water at initial planting after which the subsequent watering was dependent on evaporation rate in the growth shelter. Ten seeds were planted in each pot ten days after planting; the ten plants were thinned down two plants with equal spacing in each pot till 12 weeks after for the final harvest for biomass weight production. The experiment was laid out in Complete Randomized Design (CRD), with 6 treatments replicated 3 times to give a total of 18 pots. Table 1 below shows the treatment combinations that were imposed on the soil.

Table 1: Treatment Application Detail

Treatment Code	**Treatment Combination**
F_{Ctr} + T	Soil + Tomato
F_{Ctr} + M	Soil + *Moringa oleifera*
F_{Ag} + T	*Ageratum conyzoid* + Tomato
F_{Ag} + M	*Ageratum conyzoid* + *Moringa oleifera*
F_{Crot} + T	Crotolaria + Tomato
F_{Crot} + M +	Crotolaria + *Moringa oleifera*

Key: Ct = Control, Ag = Ageratum Biofertilizer, T = Tomato, Crot = Crotalaria Biofertilizer, M = Moringa

Data Collection

Agronomic data were collected on percentage of seed germination and plant biomass production, while biological data were collected on the total microbial population using Bunt and Rovira medium (Bunt *et al*., 1955). All data generated from the study were then subjected to ANOVA using SPSS version 20, and the mean difference of the effects of the biofertilizers on soil properties and plant biomass were separated using Duncan Multiple Range Test method and compared using the least significant difference ($LSD_{0.05}$) as described by Obi (2002).

RESULTS

Table 2 shows some physicochemical properties of Igbariam soil at the start of the experiment. The soil was found to be infertile for crop production, acidic, low buffer capacity, low pH and electrical conductivity with low cation exchange capacity and high exchange acidity. Due to all these deficiencies the soil of this class needs serious improvement which can be actualized by application of biofertilizer and biopesticides.

Table 2. Some physicochemical properties of the Igbariam soil

Soil Properties	Values
Sand (%)	80.80±6.12
Silt (%)	3.20±0.15
Clay (%)	16.0±3.63
Textural Class	Sandy Loam
Dispersion Ratio (%)	36.00±6.00
Aeration Porosity (v/v)	11.08±2.32
Total Porosity (v/v)	22.60±4.32
Bulk Density (g/cm^3)	1.98±0.01
Field Capacity (v/v)	25.10±5.40
Plant Available Water (%)	16.53±2.22
pH (H_2O)	4.10±1.00
pH (KCL)	3.43±0.56
Base Saturation (%)	40.0±1.05
Buffer Capacity (meq/100)	0.23±0.00
Cation Exchange Capacity (meq/100g soil)	8.16±0.04
Soluble Cation (Cmol/kg)	0.025±0.00
Exchangeable Acidity (meq/100g soil)	3.25±0.01
Electrical Conductivity (µs/cm)	10.00±1.00

The result in Table 3 shows chemical and biological properties of the biofertilizers used at the start of the experiment. The table shows that the biofertilizer itself has optimum chemical and biological properties in order to address the infertility nature of the experimental soil for crop production and increase in biological activities.

Table 3: The Chemical and Biological Properties of the biofertilizers used for the trial

Properties	*Ageratum spp.*	*Crotalaria spp.*
pH (H2O)	7.00	6.95
Organic Carbon (%)	5.26	5.09
Total Nitrogen (%)	0.53	0.50
Available Phosphorus (ppm)	0.05	0.05
Microbial Population	1.33 x 10^5	1.67 x 10^5

Table 4 shows the percentage emergence and dry biomass weight at 10 DAP and 60 DAP respectively. From the result, the percentage emergence did not differ significantly; this is evidenced from the fact that the plant does not necessarily need fertilizer for its emergence unlike the emergence rate, the biomass production of the biofertilizer treated plants differs significantly when compared to the control plants. This study could be explained that the biofertilizers enhanced the soil properties as well as increased the plant biomass production at 10 DAPS and 60 DAP respectively. Organic additions to soil have long been considered important in maintaining the quality of both natural and managed soils, principally because of their role in providing nutrients to the soil.

Table 4: Germination Percentage and Dry Biomass weight at 10 DAP and 60 DAP, respectively

Treatment	Emergence Percentage (%)	Dry Biomass 10 DAP (g)	Dry Biomass 60 DAP (g)
Ctr+T	100.00±0.00^{e}	0.08±0.01^{a}	0.14±0.04^{a}
Ctr+M	90.00±10.00^{c}	2.12±0.10^{c}	3.64±0.56^{d}
Ag+T	93.33±5.77^{d}	0.50±0.20^{b}	1.00±0.61^{c}
Ag+M	73.33±28.87^{b}	3.99±2.75^{d}	6.06±4.66e
Crot+T	90.00±0.00^{c}	0.55±0.09^{b}	0.74±0.20^{b}
Crot+M	66.67±5.77^{a}	3.08±0.39^{d}	7.96±1.49^{f}
$LSD_{0.05}$	NS	NS	**

** = Significant at P < 0.05, NS = not significant. Key: Ct = Control, Ag = Ageratum Biofertilizer, T = Tomato, Crot = Crotalaria Biofertilizer, M = Moringa

Table 5 shows microbial population of the soil after harvesting. The result in the table shows that there statistical difference between the microbial populations of the biofertilizer treated soil when compared with the control soil. This is evidenced from the fact that one of the most important effects of biofertilizer is the promotion of soil microbes . A great variety of organisms exists within the soil ranging from large, visible organisms to organisms, which can only be viewed under a powerful microscope. These organisms perform a wide range of functions, which are major contributions to what we consider normal and healthy soil. It might be reasonably said that these organisms have essential roles in determining the functioning of the soil system, but this functioning is dependent upon a supply of available carbon. In this context, biofertilizer has a stimulation effect on both the microbial community in the biofertilizer substrate as well as the soil-born micro biota of soils. As reported by Brown and Cotton, (2011), the application of compost has increased microbial population (5.65 x 10^{5}±30413.81) in comparison to the control soils (3.48 x 10^{4}).

Table 5: Microbial population of the Soil after harvesting

Treatment	Microbial Population
Ctr+T	5 x 10^{5}±13228.76^{b}
Ctr+M	5.1 x 10^{5}±10000.00^{a}
Ag+T	5.58 x 10^{5}±2000.00^{e}
Ag+M	5.65 x 10^{5}±30413.81^{f}
Crot+T	5.42 x 10^{5}±2000.00^{d}
Crot+M	5.46 x 10^{5}±2000.00^{c}
$LSD_{0.05}$	**

** = Significant at P < 0.05, NS = not significant. Key: Ct = Control, Ag = Ageratum Biofertilizer, T = Tomato, Crot = Crotalaria Biofertilizer, M = Moringa

DISCUSSION

Biofertilizer effect on soil biological properties

One of the most important effects of biofertilizers use is the promotion of soil biology. A great variety of organisms exists within the soil ranging from large, visible organisms to organisms, which can only be viewed under a powerful microscope. These organisms perform a wide range of functions, which are major contributions to what we consider normal and healthy soil. It might be reasonably said that these organisms have essential roles in determining the functioning of the soil system, but this functioning is dependent upon a supply of available carbon. In this context, compost has a stimulation effect on both the microbial community in the biofertilizer substrate as well as the soil-born micro biota of soils. As reported by Brown and Cotton, (2011), the application of biofertilizers has increased microbial activity in comparison to the control soils. They observed microbial activity was 2.23 times greater in the biofertilizers amended soils as compared to the control soils, because organic matter found in biofertilizers provides food for microorganisms. Paul (2003) had conducted an experiment on long-term effects of biofertilizers and mineral fertilizers on soil biological activity and observed microbial activity was enhanced in biofertilizers treated field plots. In his trial, soil fertility was enhanced in the organic plots compared to the conventional plots as indicated by a higher microbial biomass, earthworm biomass and enhanced mycorrhizal root colonization. Moreover, the functional diversity of soil microorganisms and their efficiency to metabolize organic carbon sources was increased in the organically fertilized systems with highest values in the biofertilizers soils.

Biofertilizers effect on crop productivity

Due to its multiple positive effects on the physical, chemical and biological soil properties, biofertilizer contributes to the stabilization and increase of crop productivity and crop quality (Tayebeh *et al*., 2010 and Amlinger *et al*., 2007). Long-term field trials proved that biofertilizers has an equalizing effect of annual/seasonal fluctuations regarding water, air and heat balance of soils, the availability of plant nutrients and thus the final crop yields (Amlinger *et al*., 2007). However, crop yields after biofertilizers application were mostly lower when compared to mineral fertilization (Agegnehu *et al*., 2014 and Amlinger *et al*., 2007), at least during the first years. This can be explained by the slow release of nutrients (especially N) during mineralization of compost. Mohammed *et al*. (2004) has compared the use of composted organic wastes as alternative to synthetic fertilizers for enhancing crop productivity and agricultural sustainability in two season (wet and dry). This was an indication that additional application suppressed the grain production probably due to lush green vegetative growth that was observed during the growing season (Mohammed *et al*., 2004). Moreover, biofertilizer increases available form of nutrients for plant in soil and then increases growth and nutrient uptake by plant that results in plant stem height and dry weight (Soheil *et al*., 2012). Gamal (2009) also reported that application of 5 t/ha biofertilizers increased sorghum grain yield by 45% as compared to no biofertilizers plots, while the grain yield was higher at biofertilized plots (10 t/ha) by 19% than no biofertilized plots in different sites. Gemal (2009) observed that the quality of corn crop was improved as the result of increasing biofertilizers application rate. Tayebeh *et al*. (2010) also observed that biofertilizers had a significant effect on seed protein and the maximum amount of seed protein was observed in 60mg biofertilizer/ha treatment.

CONCLUSION

The results showed significant increases in plant growth and biomass production for all the treatment tested during the research seasons but the most consistent results were achieved by the *Ageratum spp.*-based biofertilizer. In most cases, the observed plant growth and biomass increases were not huge (0.2 to 0.5 $t \cdot ha^{-1}$) but could provide substantial income gains given the relatively low costs of all biofertilizers tested. The positive effect of the tested biofertilizers on soil biological properties was tremendous. The results achieved can already be used to develop better advice for farmers on biofertilizer use in Moringa and tomato production, but several important questions remain. In particular, biofertilizers need to be evaluated under conditions with abiotic stresses typical for most low- to medium-input systems (e.g., under drought or low soil fertility) and with a range of germplasm because their effect might depend also on the variety used.

RECOMMENDATION

More upstream-oriented research would be needed to better understand the actual mechanisms involved, which in turn could also contribute to making the best use of biofertilizers in moringa and tomato production.

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